THERMAL STABILITY OF HYDROCARBON FUELS

PROGRESS REPORT NO. 9

AIR FORCE CONTRACT AF 33(657)-10639

MARCH, 1966

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RESEARCH AND DEVELOPMENT DEPARTMENT

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SUMMARY

This report concerns work performed during the quarterly period December 1, 1965 through February 28, 1966 under Air Force Contract AF 33 (657)-10639.

A program to investigate the effect of storage time and temperature on changes in thermal stability quality as measured by the CRC-Modified (SSF) Coker for five widely different fuel types continues to show no deterioration of any fuels after 100 weeks at 40°F storage or 72 weeks at ambient field conditions. The distillate fuels (four of the five) show no serious deterioration after 54 weeks at 130°F or after 36 days at 180°F storage. A synthetic fuel, HF Alkylate containing about 2 per cent olefins showed a rapid rate of deterioration of about 100°F within 6 days at 180°F, and a moderate rate of deterioration of about 100°F within 54 weeks at 130°F. Removal of dissolved oxygen (to less than 1 ppm) from the HF Alkylate fuel prior to storage prevented deterioration.

Evaluation of the storage behavior of these fuels with Phillips 5-ml Bomb procedure resulted in remarkable agreement with the SSF Coker evaluations. The rate of deterioration curves for the 5 fuels at 4 different storage temperatures (20 total) for fuel samples stored in the absence of dissolved oxygen were identical. For aliquot fuel samples stored in the presence of dissolved oxygen only two evaluations (out of 20) could be considered major differences. A consideration of data in the literature relative to the contribution of antioxidants to storage deterioration suggests that in the two instances where the 5-ml Bomb differs with the Coker evaluations, the 5-ml Bomb would be the more accurate evaluation.

The statistical relationships between the Minex, 5-ml Bomb, and Coker fuel performance ratings have been studied. The analysis was based upon all available Minex evaluations of JP fuel thermal stability (30 fuels) and relevant ratings of threshold failure temperature by the 5-ml Bomb and Coker. From this analysis, we can state with over 99 per cent confidence that there is a linear thermal relationship between 5-ml Bomb vs Minex and 5-ml Bomb vs Coker ratings. Both of these relationships may be of numerical equality. Indications are that the precision of the 5-ml Bomb procedure is probably better than that of either the Minex or Coker.

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S U M M A R Y (Continued)

Since the 5-ml Bomb procedure evaluates storage and thermal stability quality equal to or better than the more complex and time-consuming Minex and Coker procedures it is recommended that it be used for monitoring these qualities of JP fuels.

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PHILLIPS PETROLEUM COMPANY

BARTLESVILLE, OKLAHOMA

THERMAL STABILITY OF HYDROCARBON FUELS

Progress Report No. 9

For

Air Force Contract AF 33(657)-10639

I. INTRODUCTION

This report is concerned with activities during the quarterly period December 1, 1965 through February ~~28~~, 1966 under Air Force Contract AF 33(657)-10639.

~~Work was continued during this period on~~ the program ~~to evaluate~~ of evaluating the effect of storage temperature, storage duration, and dissolved oxygen content on thermal stability quality of five aviation turbine fuels. Thermal stability quality of the storage fuels is being determined by the CRC-Modified (SSF) Coker and Phillips 5-ml Bomb procedure.

To determine if Phillips 5-ml Bomb procedure is as reliable as the Coker and the Minex for measuring thermal stability quality, statistical analyses are shown in this report for the relationships that exist between the respective critical temperature ratings for (1) 5-ml Bomb vs. Minex; (2) 5-ml Bomb vs. Coker; (3) Coker vs. Minex.

Previous work in these areas along with related studies under this contract are given in References 1 through 10.

II. STORAGE PROGRAM

The aim of the present storage program is to determine if various aviation turbine fuels, selected to span a range in thermal stability quality from 300°F to 700°F, are susceptible to reactions during storage that would significantly lower the thermal stability quality of the fuels. Since deterioration is possibly time and temperature dependent and dissolved oxygen sensitive, the selected fuels have been stored at various temperatures in both an air-saturated state (40-100 ppm) and a dissolved-oxygen-removed state (<1 ppm) and are being tested periodically. The procedure for removing dissolved oxygen and preparing fuels for storage are described in References 3, 4 and 8.

Thermal stability quality is measured by the SSF Coker in terms of a threshold failure temperature which is defined as the minimum preheater outlet temperature required to develop a colored deposit equivalent to a 3 color code (ASTM Method D 1660) as observed in a Tuberator produced by Eppi Precision Products, Inc. or 10 inches pressure rise across the filter. Storage

stability quality is measured by the magnitude of the change in thermal stability quality resulting from storage.

A. Storage Fuels

The test fuels selected for this study are:

Storage Fuel No. 1-(BJ63-10-B75). Phillips Base Oil No. 1 is a kerosine boiling range fraction of HF Alkylate, isoparaffinic in structure and low in aromatics. This fuel contains no additives.

Storage Fuel No. 2-(BJ63-10-G74). CRC SST Rig Fuel No. 1 is an "average quality" commercial turbine fuel, ASTM Type-A, supplied by Standard Oil Company of California. This fuel contains no additives.

Storage Fuel No. 3-(BJ64-10-G71). Texaco SO_2 extracted naphthenic kerosine. This fuel contains 5 lbs/1000 barrels of 2,6 ditertiary-butyl-4-methyl phenol (26B4M) antioxidant and 2 lbs/1000 barrels N,N'-disalicylidene-1, 2-propane-diamine metal deactivator (MD) additives.

Storage Fuel No. 4-(BJ64-10-G107). Texaco SO_2 extracted paraffinic kerosine. This fuel contains 5 lbs/1000 barrels N,N'-disecondary-butyl-paraphenylene-diamine (PD), antioxidant and 2 lbs/1000 barrels of MD additives.

Storage Fuel No. 5-(BJ64-10-G166). Hydrotreated West Texas kerosine supplied by Phillips. A portion of this fuel was collected from the refinery unit without exposure to the atmosphere (< 1 ppm dissolved oxygen) and is being maintained under a nitrogen blanket. This fuel contains no additives.

B. Physical and Chemical Properties of Storage Fuels

The methods used in Phillips laboratory to determine the physical and chemical properties are shown in Table 23 and the results are shown in Table 24. These data indicate that the fuels selected for this program are markedly different in (1) total potential gum, (2) total sulfur, (3) aromatics, (4) total nitrogen (5) trace copper, (6) lead, (7) water, (8) phenols, (9) total oxygen, (10) thermal stability (SSF Coker data) and (11) olefin content. In addition to these properties the fuels selected are representative of different substrates (paraffinic, naphthenic and isoparaffinic); and are also representative of fuels containing (1) no additives, (2) phenol-type and (3) amine-type additives. An attempt will be made to relate changes in storage stability quality of these fuels to their variation in physical and chemical properties and additive composition.

C. Storage Conditions

Evaluation of storage stability quality of the fuels described above is being made by periodically determining threshold failure temperatures (by the SSF Coker and 5-ml Bomb configurations) during storage at 40°F (ice house), ambient (field storage), 130°F (hot room), and 180°F (water bath).

D. SSF Coker Storage Results

SSF Coker data for all aging conditions obtained since the last report[10] are shown in Tables 6 through 17. A summary of all threshold failure temperatures for these fuels is shown in Table 1.

TABLE 1

SSF COKER THRESHOLD FAILURE TEMPERATURES OF STORAGE FUELS

Storage Temp., °F	Storage Time	SSF Coker TFT of Storage Fuels[a], °F — Fuels Stored After Air Saturation 1	2	3	4	5	Fuels Stored and Tested With Dissolved O_2 Removed 1	2	3	4	5
40	72 Weeks	650	380	725	712	425	-	-	-	-	675
	100 Weeks	625	355	725	725	450	-	-	-	-	675
Ambient	Initial	625	332	712	692	425	685	525	700	700	700
Ambient	36 Weeks	563	355	725	700	432	725	500	737	725	712
Ambient	72 Weeks	600	355	700	725	425	650	550	738	725	688
Ambient	100 Weeks										
130	6 Weeks	600	350	725	675	438	650	575	700	725	750
130	22 Weeks	587	348	733	700	450	725	588	742	712	688
130	54 Weeks	512	333	663	712	450	700	575			
180	6 Days	517	333	725	725	437	-	-	-	-	-
180	18 Days	538	310	675	700	432	700	550	762	737	725
180	36 Days	535	333	712	675	450	685	550	750	725	675
180	54 Days	513	333	450	625	675					

Note: Blank spaces represent data to be obtained. It is not planned to obtain data for dashed spaces.

(a) Test fuels in this program are described as follows:

No. 1: Phillips Base Oil #1 (alkylate)
No. 2: SST Rig Fuel #1 (RAF 176-63)
No. 3: Texaco Naphthenic Kerosine
No. 4: Texaco Paraffinic Kerosine
No. 5: Phillips West Texas Hydrotreated Kerosine

The effect of storage duration and storage temperature on the thermal stability quality of the aerated fuels stored in air-sealed drums is shown graphically in Figure 1. These data were plotted such that the size of the data points approximates the previously determined[9] standard deviation of ± 24.1°F which was based on the assumption that no deterioration occurred at 40°F, ambient, or through 22 weeks at 130°F storage. Using the standard deviation as a criterion for repeatability Figure 1 shows that Storage Fuel 1, an HF alkylate containing about two per cent olefins, shows an improvement during 40°F storage; no deterioration up to 72 weeks ambient; a slow rate of deterioration at 130°F; and a rapid rate at 180°F. The maximum loss in thermal stability quality does not exceed 100°F at either 130°F or 180°F storage. Using the regression lines representing the points it appears that 52 weeks storage at 130°F is equivalent to about 8 weeks at 180°F.

Storage Fuel 2, RAF-176-63, which was reported to be unstable during ambient storage shows, no deterioration in this study up to 100 weeks at 40°F, 72 weeks ambient, 54 weeks at 130°F and 54 days at 180°F.

Storage Fuel 3, an SO_2 extracted naphthenic kerosine containing a phenolic antioxidant plus metal deactivator is storage stable up to 100 weeks at 40°F, 72 weeks at ambient and 36 days at 180°F. This fuel appears to be deteriorating very slightly after 54 weeks at 130°F, but the magnitude of this loss, if real, is not considered serious.

Storage Fuel 4, an SO_2 extracted naphthenic kerosine containing an amine type antioxidant plus metal deactivator shows no deterioration up to 100 weeks at 40°F, 72 weeks at ambient, 54 weeks at 130°F, and 36 days at 180°F.

Storage Fuel 5, a West Texas hydrotreated kerosine, shows no deterioration up to 100 weeks at 40°F, 72 weeks ambient, 54 weeks at 130°F and 54 days at 180°F.

It is observed from these data that none of the fuels in this program show any significant changes in storage stability quality at ambient field conditions. It is also recognized that none of the <u>distillate</u> fuels (Storage Fuels 2, 3, 4 and 5) show any serious deterioration at the elevated storage temperatures included in this program. From these observations it is concluded that the reported problem of storage instability for distillate-type jet fuels must be the results of (1) contamination and/or (2) exposure during storage to unlimited air such as occurs in the use of vented tanks and/or (3) poor repeatability and reproducibility of Coker measurements.

Figure 2 shows graphically the effect of storage duration and storage temperature on thermal stability quality for the aliquot samples of the fuels discussed above which were stored (and tested) with less than one part per million dissolved oxygen. It is noted that there are slightly greater deviations from the indicated regression lines which is expected in view of earlier findings[9] that, at very low concentrations of dissolved oxygen, thermal stability is extremely sensitive to small changes in dissolved oxygen. Consequently slight differences in dissolved oxygen content at the time of storage could account for the observed deviations. Overall it is apparent from these data that no serious deterioration occurs at any of the storage conditions in any of the fuels. This emphasizes that dissolved oxygen is an important contaminant affecting storage deterioration, and suggests that the removal of dissolved oxygen prior to storage, and prohibition of air exposure during storage is a preventive measure that can eliminate storage deterioration.

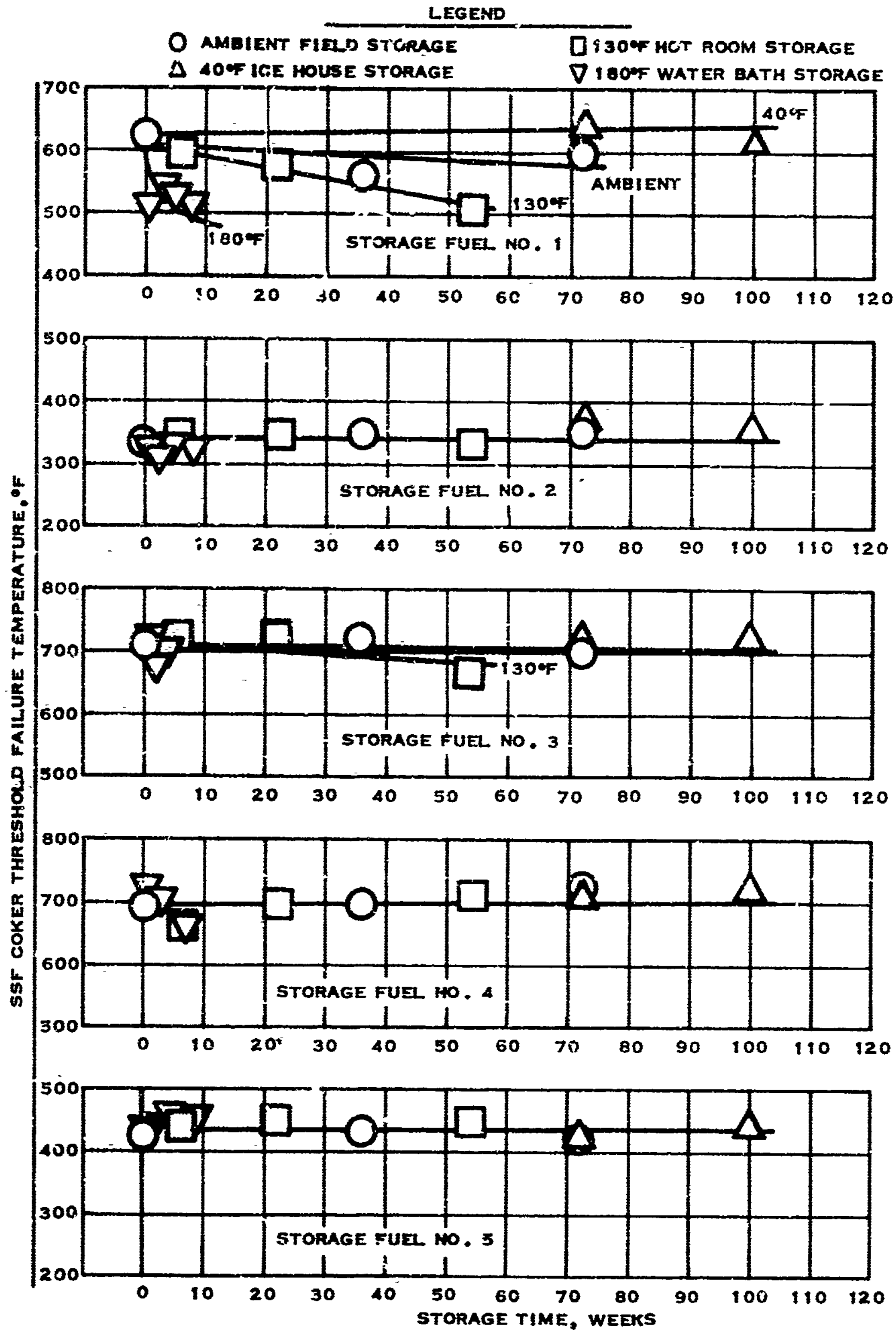

FIGURE 1 EFFECT OF STORAGE TIME AND TEMPERATURE ON THERMAL STABILITY OF AERATED JET FUELS AS MEASURED BY SSF COKER

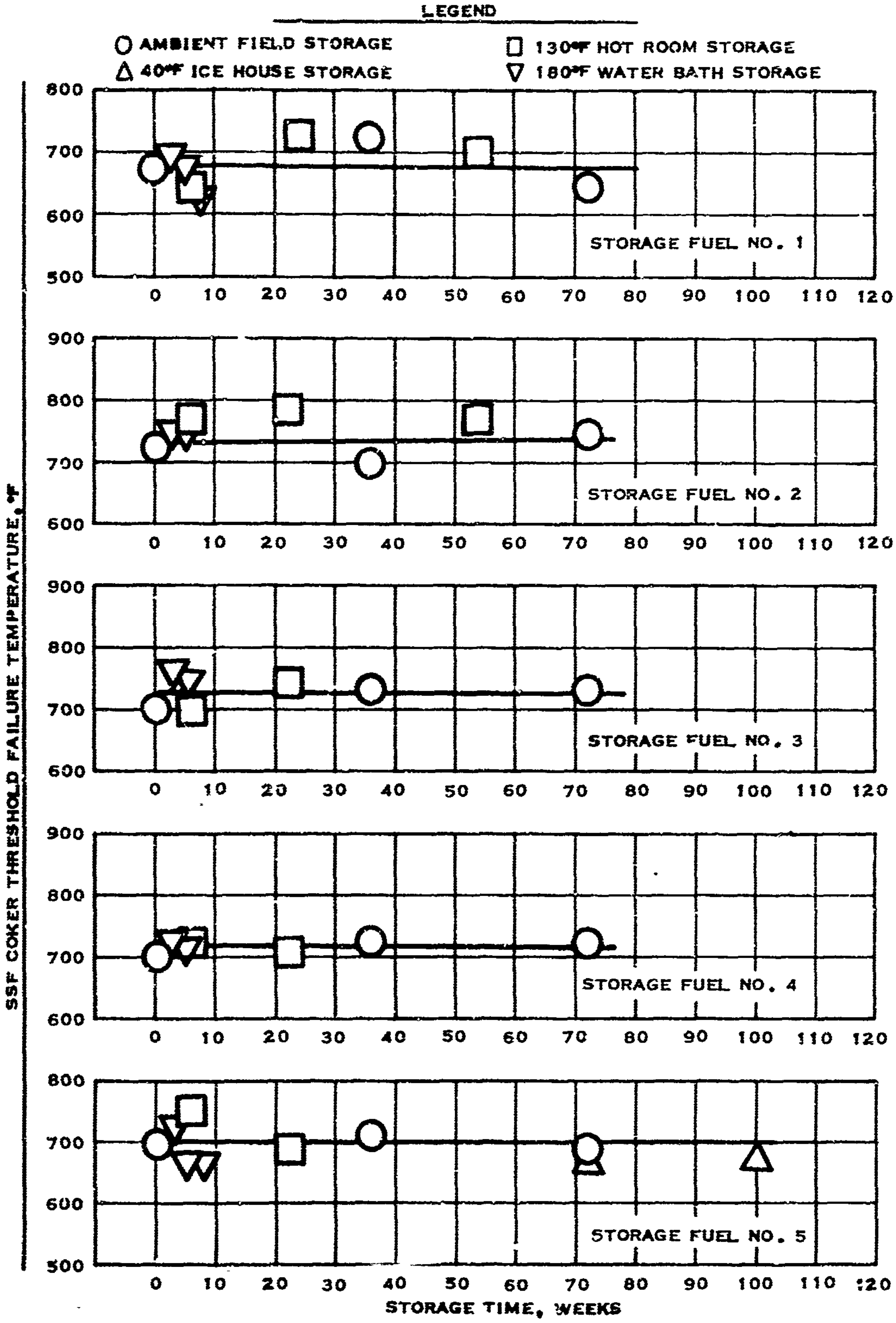

FIGURE 2 EFFECT OF STORAGE TIME AND TEMPERATURE ON THERMAL STABILITY OF JET FUELS WITH DISSOLVED OXYGEN REMOVED PRIOR TO STORAGE AS MEASURED BY SSF COKER

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E. 5-Ml Bomb Storage Results

Concurrently with SSF Coker determinations of the fuels in the storage program, 5-ml Bomb determinations were also made and all data obtained since last report are shown in Tables 18 and 19. (For a complete description of Phillips 5-ml Bomb procedure see Reference 8.) A summary of all the thermal stability data for the storage fuels is shown in Table 2.

A graphical representation of the effect of storage duration and storage temperature on thermal stability quality of the aerated fuels stored in air-sealed drums as measured by the 5-ml Bomb procedure is shown in Figure 3. For this presentation the repeatability of 5-ml Bomb measurements is assumed to be about ± 25°F.

Storage Fuel 1, an HF alkylate, containing about 2 per cent olefins, shows an improvement in thermal stability quality during storage at 40°F; no deterioration during ambient field storage up to 72 weeks; a moderate rate of deterioration at 130°F; and a rapid rate of deterioration at 180°F. The maximum loss in thermal stability quality does not exceed 100°F at either 130°F or 180°F storage. Using the regression lines representing the data points, it appears that storage at 130°F for 54 weeks is equivalent to about 7 weeks at 180°F.

Storage Fuel 2, RAF 176-63, shows no deterioration up to 100 weeks at 40°F; 72 weeks at ambient; 54 weeks at 130°F, or 54 days at 180°F.

Storage Fuel 3, SO_2 extracted naphthenic kerosine containing a phenolic antioxidant and metal deactivator shows no deterioration at 40°F and progressively greater rates of deterioration at ambient, 130°F and 180°F. The maximum loss in thermal stability after 72 weeks at ambient is a marginal 40°F; after 54 weeks at 130°F is about 60°F and about 80°F after about 8 weeks at 180°F.

Storage Fuel 4, SO_2 extracted paraffinic kerosine containing an amine type antioxidant shows no deterioration at 40°F, ambient, or 130°F and a rapid rate of deterioration at 180°F. The maximum loss in thermal stability q ity after about 8 weeks at 180°F is about 100°F.

Storage Fuel 5, West Texas hydrotreated kerosine, shows no serious loss in thermal stability quality during storage at either 40°F, ambient, 130°F or 180°F.

Figure 4 shows graphically the storage data results using the 5-ml Bomb for aliquot fuels samples which were stored (and tested) with less than one part per million dissolved oxygen. The data points in this figure, show much less deviations from the regressions than was found for the SSF Coker data (Figure 2) and which indicates that the dissolved oxygen content is stabilized by the 50 psig nitrogen pressurization used in the 5-ml Bomb procedure. Again these data verify that in general fuels which deteriorate during storage in the presence of oxygen can be made storage stable if the dissolved oxygen is reduced to less than one part per million prior to storage and maintained throughout storage in this environment.

TABLE 2

5-ML BOMB THRESHOLD FAILURE TEMPERATURES OF STORAGE FUELS

Rating Criterion: Temperature which effects 25 per cent loss in light transmittance at 350 millimicrons wave length.

Storage Temp., °F	Storage Time	5-Ml Bomb TFT of Storage Fuels[a], °F — Fuels Stored After Air Saturation 1	2	3	4	5	Fuels Stored and Tested With Dissolved O_2 Removed 1	2	3	4	5
40	72 Weeks	563	388	477	550	495	-	-	-	-	865
40	100 Weeks	574	372	499	551		-	-	-	-	
Ambient	Initial	503	395	517	526	471	773	865	822	835	874
Ambient	36 Weeks	450	377	448	502	450	776	870	840	868	874
Ambient	72 Weeks	476	383	476	517	422	721	882	830	890	854
Ambient	100 Weeks										
130	6 Weeks	479	394	440	491	477	787	-	822	864	855
130	22 Weeks	415	373	440	483	468	737	869	834	867	843
130	54 Weeks	413	358	476	551	447					
180	6 Days	410	391	507	525	446	-	-	-	-	-
180	18 Days	420	352	465	442	449	747	871	840	875	875
180	36 Days	479	383	431	488	453	778	835	835	905	884
180	54 Days	458	374			496	733				

Note: Blank spaces represent data to be obtained. It is not planned to obtain data for dashed spaces.

(a) Test fuels in this program are described as follows:

No. 1: Phillips Base Oil #1 (alkylate)
No. 2: SST Rig Fuel #1 (RAF-176-63)
No. 3: Texaco Naphthenic Kerosine
No. 4: Texaco Paraffinic Kerosine
No. 5: Phillips West Texas Hydrotreated Kerosine

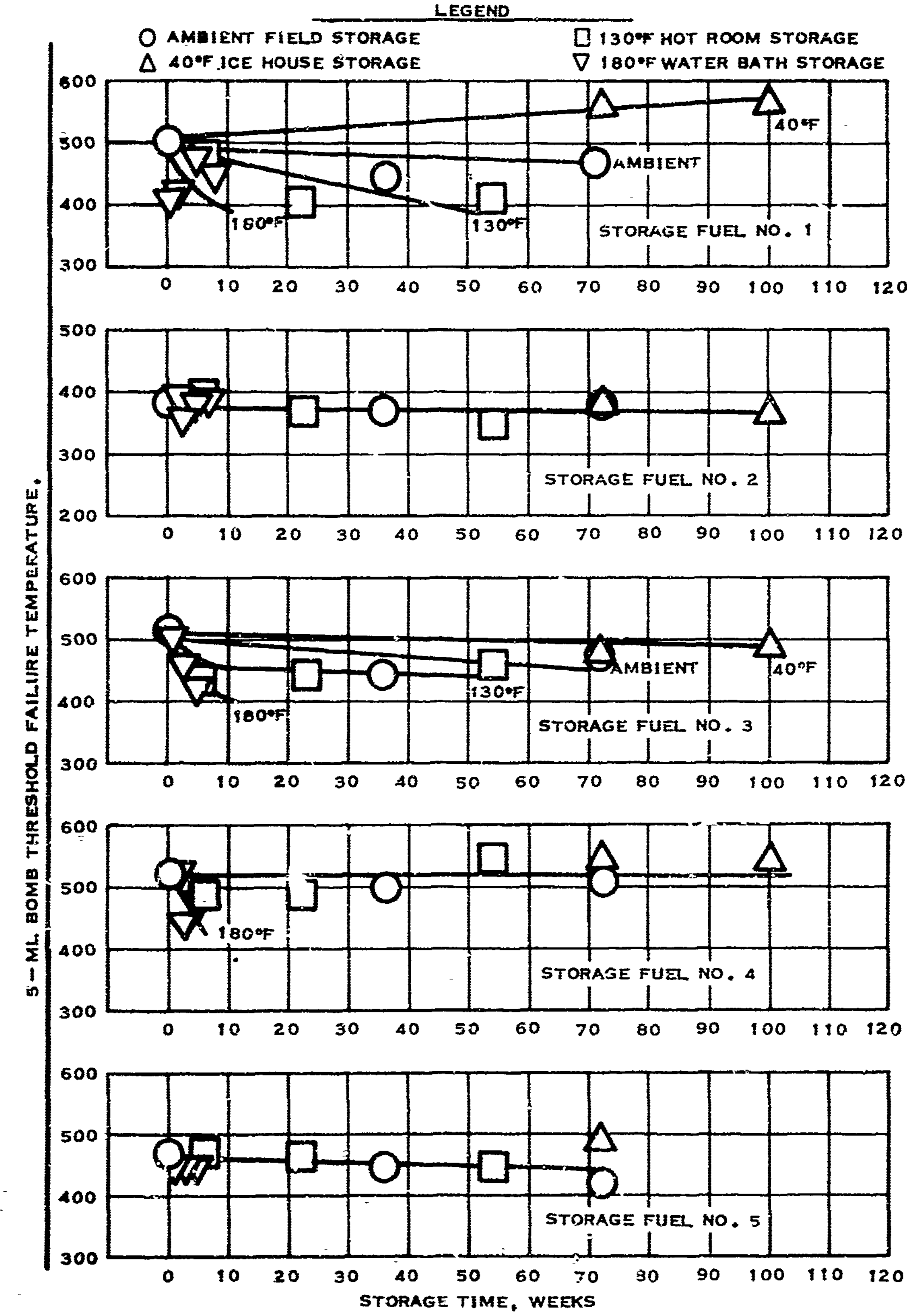

FIGURE 3 EFFECT OF STORAGE TIME AND TEMPERATURE ON THERMAL STABILITY OF AERATED JET FUELS AS MEASURED BY PHILLIPS 5-ML BOMB

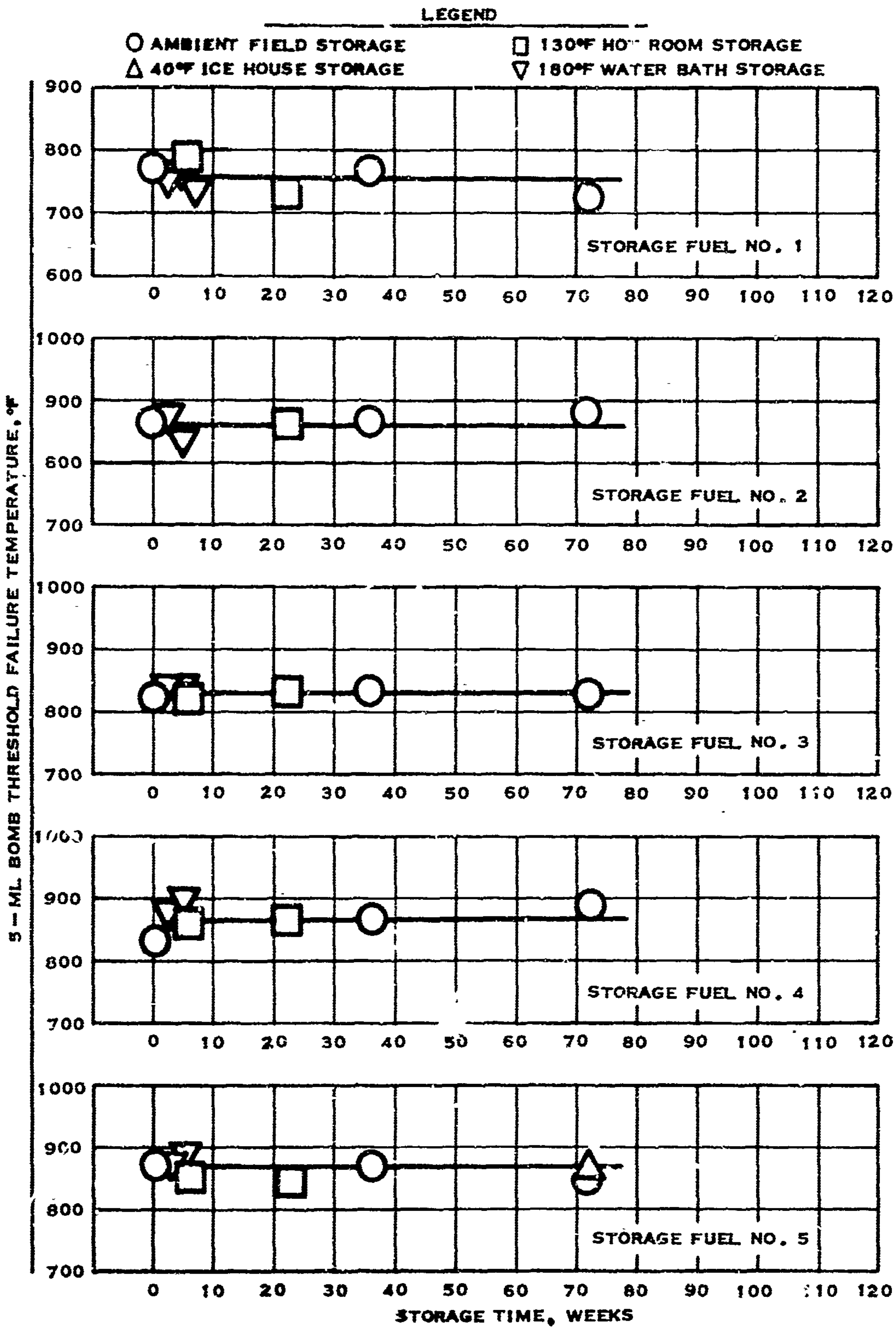

FIGURE 4 EFFECT OF STORAGE TIME AND TEMPERATURE ON THERMAL STABILITY OF JET FUELS WITH DISSOLVED OXYGEN REMOVED PRIOR TO STORAGE AS MEASURED BY PHILLIPS 5–ML BOMB

F. Comparison of SSF Coker and 5-Ml Bomb Storage Data

The primary objective of the storage program is to determine the storage behavior of jet fuels covering a range in thermal stability quality of 300-700°F as measured by the SSF Coker. A second objective is to determine how effective the much simpler 5-ml Bomb procedure evaluates the storage stability quality of the same fuels. As shown in Figures 2 and 4 for fuels stored in the absence of dissolved oxygen the evaluation of storage stability quality by these two procedures is identical. For fuels stored in an air environment it is observed from Figures 1 and 3 that the two procedures are very similar in their evaluations. To aid in interpreting these results Table 3 shows a comparison of the two procedures based on a qualitative evaluation of the rate of change in thermal stability quality for each of the storage fuels at each storage temperature i.e., 5 fuels at 4 different storage temperatures for a total of 20 possible rate curves.

TABLE 3

COMPARISON OF 5-ML BOMB AND SSF COKER EVALUATIONS OF STORAGE STABILITY QUALITY

Fuels Stored in an Air Environment

Storage Fuel	Storage Temp., °F	Storage Stability Quality Evaluation: 5 ml Bomb	SSF Coker	Notes
No. 1	40	I	I	
	Ambient	N	N	
	130	M	M	
	180	R	R	
No. 2	40	N	N	
	Ambient	N	N	
	130	N	N	
	180	N	N	
No. 3	40	N	N	
	Ambient	S	N	Difference in rates is marginal
	130	M	S	Magnitude of loss nearly equivalent at 54 weeks.
	180	R	N	Major difference
No. 4	40	N	N	
	Ambient	N	N	
	130	N	N	
	180	R	N	Major difference
No. 5	40	N	N	
	Ambient	N	N	
	130	N	N	
	180	N	N	

I Improvement in thermal stability quality (TSQ) during storage.
N No change in TSQ during storage.
S Slight rate of loss in TSQ during storage.
M Moderate rate of loss in TSQ during storage.
R Rapid rate of loss in TSQ during storage.

This comparison shows that the 5-ml Bomb evaluates the storage stability quality of 16 of the 20 possible conditions identically like that of the SSF Coker; at two conditions there are marginal differences; and at only two conditions major differences are observed. The major differences occur with the evaluations of the additive-containing fuels (Storage Fuels 3 and 4) at 180°F storage conditions. These fuels contain, in addition to metal deactivator, 2,6-ditertiary butyl-4-methyl phenol (26 B4M) and N,N'-disecondary-butyl paraphenylene-diamine (PD) antioxidants respectively. Evidence is found in the literature which indicates that the effect of antioxidants on storage stability quality is dependent on the test method used for evaluation. For example Kittredge(11) and Johnston(12) both show that 26B4M and similar additives are not detrimental to storage stability quality at 130°F storage temperature as measured by Coker techniques which supports our findings in this work with the SSF Coker. Whisman(13) however, using radioactive trace techniques to study deposits formed by thermally stressing ten different fuels in a bomb shows that the antioxidant 26B4M is unstable during 130°F storage for 26 weeks and participates to the "fullest extent" in reactions leading to deposits. Since participation of the 26B4M antioxidant in the deposits formed by thermal stressing was much lower prior to storage, Whisman's work suggests that 26B4M is detrimental to storage stability quality of fuels at 130°F storage temperature. It should be noted in Figure 3 that the 5-ml Bomb procedure also recognizes this loss in storage stability quality during 130°F storage for Storage Fuel 3 which contains the 26B4M antioxidant. At 180°F storage Figure 3 shows, in addition to Storage Fuel 3, that the PD-additive fuel (Storage Fuel 4) is also detrimental to storage stability quality.

Since these data indicate that the evaluation of storage stability quality depends on the test method, it becomes necessary to determine which procedure is more accurate. The final assessment of the accuracy of the test procedure will have to come from actual aircraft engine performance data. However, at this point it would appear that methods, which measure fundamental changes in the chemical structure of compounds entering into deterioration reactions such as measured by radioactive tracer techniques and light transmittance changes (5-ml Bomb procedure) should be considered more valid assessments than Coker techniques which rely on visual color changes of deposits on a metal surface. Consequently, the 5-ml Bomb procedure should be recognized as an acceptable storage stability rating procedure. Data will also be presented in this report to show its capabilities to evaluate JP fuel thermal stability quality.

III. CORRELATION STUDY OF SMALL-SCALE TEST METHODS FOR EVALUATING THE THERMAL STABILITY QUALITY OF JP FUELS

There is an obvious need for improvement in the measurement of JP fuel thermal stability quality. A shortcoming of present specifications is the simple "pass-or fail" rating criterion, which does not require determination of a specific threshold failure temperature. It can be attributed to the large sample (5 gallons) and long time (8 hours) required to obtain a single point on the fuel temperature vs. fuel performance curve using the ASTM standard method of test D1660-64. It is further complicated by precision which is poor and has not yet been fully determined. This has resulted in meager, and frequently misleading, information concerning the initial level of thermal stability quality of JP fuels and subsequent changes in that level.

One area of interest in our work under this contract concerns the degree of association between the 5-ml Bomb procedure, which we have developed[8] for evaluating the thermal stability quality of JP fuels, and other small-scale test methods. Of all the small-scale test methods presently being considered, the 5-ml Bomb is by far the most economical of equipment, manpower, time, and fuel sample. Using it, a non-technical man can establish the usual "pass-or-fail" rating in an hour; or the complete fuel temperature vs. fuel performance curve, for a more desirable rating of the threshold failure temperature, within one 8-hour day on less than a pint of fuel. If it can be shown, with a high degree of confidence, that such an association exists, and that no loss in precision would result, it would be desirable to run regularly only the simpler test, the 5-ml Bomb. Its approval for use in monitoring JP fuel contamination during distribution, and storage, would fill a serious need. To this end, the statistical relationships between the Minex, 5-ml Bomb, and Coker fuel performance ratings have been studied.

A. Test Methods

The Minex was chosen for this study because its performance ratings of the thermal stability quality of JP fuels are considered to be the most valid attainable from the small-scale test methods which are currently available. Measurements of the change in heat transfer (h_f) characteristics of a surface being fouled by the thermal decomposition products of the fuel are made, and used to establish the rating temperature for initial loss in h_f. This is an interpolated value, obtained from a cross-plot of fuel temperature vs. per cent loss in h_f per hour. Fuel performance data were obtained from three different Minex rigs, one of which was modified by the addition of a low pressure, heated, fuel reservoir. However, a preliminary evaluation indicated that there was no reason to question the compatibility of the ratings from the different rigs, and all were treated equally in the statistical analysis.

The 5-ml Bomb ratings of threshold failure temperature are based on the temperature required to produce a 25 per cent loss in the initial light transmittance, measured at a wavelength of 350 millimicrons. This is an interpolated value, based upon 8 to 10 data points on the fuel temperature vs. loss in light transmittance curve. While all of the 5-ml Bomb ratings were made in this laboratory during the past four years, the 5-ml Bomb procedure has undergone some modification during that period to improve precision. However, a preliminary evaluation indicated that there was no reason to question the compatibility of the ratings from the different procedures, and all were treated equally in the statistical analysis.

The Coker was included in this study for reference, because it is the test method currently used in JP fuel specifications. Coker ratings of threshold failure temperature are based upon the fuel temperature at the outlet of the preheater for a Code 3 (unwiped) deposit. This is an interpolated value, obtained by plotting fuel temperature vs. maximum preheater tube deposit rating. The additional information on filter pressure drop from the Coker tests was not used in this study, since it does not bear on the fouling of heat transfer surfaces. Fuel performance ratings were obtained using three different modifications of the Coker; (1) the ASTM-CRC Coker, which has a maximum operating temperature of 450°F, (2) the CRC Research Coker, and (3) the CRC Modified (SSF) Coker. The Research Coker has a provision for operation with a heated fuel reservoir, but only data from ambient reservoir tests were used. The Modified Coker has a provision for

prestressing fuels by preheating, but no data from prestressed fuels were used. The Coker data were obtained from a wide variety of sources as shown in Table 22. A preliminary evaluation indicated that there was no reason to question the compatibility of the ratings from the different Cokers, and all were treated equally in the statistical analysis.

B. Test Fuels

A population sample of 30 different JP fuels, constituting all test fuels for which Minex data are available to us at this time, was used for this study. No attempt was made to explain any apparent discrepancies in any fuel performance ratings by any test methods, for use in selecting data. No attempt was made to compensate for differences in test equipment and/or test procedures, which exist in all three of the small-scale test methods. Where more than one rating was available on a given test fuel, by any of the test methods, it was included, but not averaged. Thus, no available ratings, on any of the test fuels, by any of the test methods, were excluded for any reason from this analysis.

A summary of all available Minex evaluations of JP fuel thermal stability quality, and relevant ratings of threshold failure temperature by the 5-ml Bomb and the Coker, is presented in Table 4. The detailed test data from which the Minex, 5-ml Bomb, and Coker ratings were derived are presented in Tables 20, 21, and 22, respectively. Graphical 5-ml Bomb data for 10 of the fuels in this study are shown in Figures 8 through 17.

Insufficient data were available on 4 of the 30 test fuels to allow an estimation of Minex fuel temperature for initial change in h_T. However, more than one Minex rating was available on three of the test fuels, which provided a total of 30 Minex ratings for the statistical analysis. This is shown in the following tabulation, along with similar information for the other test methods.

	Minex	5-ml Bomb	Coker
Number of Test Fuels with Ratings	26	29	23
Number of Ratings for Analysis	30	44	65

Where multiple ratings were available on a given test fuel, by any of the test methods, they were used in all possible combinations for the statistical analysis. Thus, 46 comparisons were possible and were used to establish the relationship between the 5-ml Bomb and Minex ratings. However, each rating was used only once in calculations to establish the precision of this relationship, which provided 28 comparisons. This is shown in the following tabulation, along with similar information for the other relationships investigated.

	5-ml Bomb vs Minex	Coker vs Minex	5-ml Bomb vs Coker
Number of Comparisons for Relationship	46	102	128
Number of Comparisons for Precision	28	25	33

TABLE 4

SUMMARY OF ALL AVAILABLE MINEX EVALUATIONS OF JP FUEL THERMAL STABILITY QUALITY AND RELEVANT RATINGS OF THRESHOLD FAILURE TEMPERATURE BY 5-ML BOMB AND COKER

Test Fuel Identification Number			MINEX RATING Fuel Temperature for Initial Change in h_f, °F			5-ML BOMB RATING Fuel Temperature for 25 % Loss in Light Transmission at 350 mμ, °F	COKER RATING Fuel Temperature for Code 3 Preheater Tube Deposit, °F		
Phillips	General Electric	Others	GE	AF	GE[a] Mod.	Phillips	ASTM	Res.	SSF[c] Mod.
BJ62-10-K30	Kerosine		350			325	388		
BJ62-10-K31	JP-6		300			337	418		
BJ63-10-G74		RAF-176-63	350	350		395	374	363	375
						388	361		
						402	338		
							367		
							370		
BJ64-10-G107		RAF-169YX-61		>625		562		700	692
						561		<450	
						516			
						463			
BJ64-10-G144		RAF-178-64	300			350	300		
						365	325		
BJ64-10-G162		RAF-174-63	445	410		395	361	354	387
			410			373	342	390	387
							388	360	368
							335	357	
							385	335	
							367		
BJ64-10-G163		RAF-175YX-63	470	490		519	437	435	450
						463		427	
								408	
BJ64-10-G166		Storage Fuel 5		475		480	425		425
						463			
BJ64-10-G234		RAF-176-64		430		384	363	363	
						383	368	375	
							384		
							394		
BJ64-10-K26		FA-S-1	305			354	338	[illegible]	
						342	368		
							325		
							363		
							350		
							325		
							313		
BJ64-10-K148		F-63-18 & 523		575		574		537	
						531			
BJ64-10-L200		RAF-159X-60	500			508		655	
BJ65-10-G46	465				284	385	375		
BJ65-10-G46A	465A				365	397	375		
BJ65-10-K25		FA-S-2A	393			451	450	467	
						429	450		
BJ65-10-K27		FA-S-2B	425			535	[illegible]		
						527	450		
BJ65-10-K62	965-1				>400	504	378		
BJ65-10-K71		RAF-176A-63		470		387	336		
						387			
BJ65-10-K72	965-2				356	40[illegible]	375		
							350		
BJ65-10-K73	965-3				332	358	388		
BJ65-10-K74	1165-1				325	450			
BJ65-10-K75	1265-1				340	388			
BJ65-10-K76	1265-2				306	366	392		
BJ65-10-K77	1265-2A				380	388	440		
BJ66-10-G1		RAF-167YX-60		600		649		<450	
BJ66-10-G2		RAF-174-63		470		392			
BJ66-10-K7	1265-3				>400	369			
BJ66-10-K8	1265-5				>400	381			
BJ66-10-K9	166-1				350	382			
		RAF-177Y-63		460				475	

(a) Fuel reservoir at 1 psia and 135°F.
(b) Ambient fuel reservoir.
(c) Fuel not prestressed.

C. Correlation Coefficients

Visual comparisons of the relationships between the fuel performance ratings are shown in Figure 5 for the 5-ml Bomb vs. Minex, Figure 6 for the Coker vs. Minex, and Figure 7 for the 5-ml Bomb vs. Coker. The 5-ml Bomb rating was chosen as the independent variable (X) in correlation studies with the Minex and Coker, because it is the easier to measure and its use for prediction of the Minex or Coker ratings is desired. The Coker rating was chosen to be the independent variable (X) in the correlation study with the Minex, because it is the current JP fuel specification test method. In particular, the general spread and shape of the points in Figure 5, where 5-ml Bomb Ratings are compared with Minex ratings, suggests more than a patternless scatter.

The degree of relationship between the fuel performance ratings determined by the three test methods was measured by calculation of correlation coefficients. The theory of linear correlation can be applied for those calculations because in each case we are concerned with a random sample of two random variables. The 99 per cent confidence interval estimate of the correlation coefficient between the various ratings is:

5-ml Bomb vs. Minex	$0.452 \leq 0.763 \leq 0.909$
5-ml Bomb vs. Coker	$0.482 \leq 0.760 \leq 0.899$
Coker vs. Minex	$0.014 \leq 0.510 \leq 0.804$

Since none of these intervals includes zero, there is reason to believe that a relationship exists in each case. However, the Coker vs. Minex relationship is much poorer than either the 5-ml Bomb vs. Minex or the 5-ml Bomb vs. Coker relationships. This indicates that the precision of the 5-ml Bomb test method is probably better than that of either the Minex or the Coker test methods.

From this analysis, we can state with over 99 per cent confidence that there is a linear thermal relationship between the loss in 350 mu light transmittance, as measured by the 5-ml Bomb, and the loss in heat transfer characteristics, as measured by the Minex, or the formation of colored deposits, as measured by the Coker.

D. Regression Analysis

The relationships between the ratings of JP fuel thermal stability quality by the Minex, 5-ml Bomb and Coker were established by regression analysis. The regression line is shown in Figures 5, 6 and 7 for the different relationships. The standard estimate of error for the regression is also shown in each figure. The 95 per cent confidence interval estimates for the mean values and for single (future) values of Minex ratings were calculated, given 5-ml Bomb or Coker ratings of 400°F. Similar estimates were made for Coker ratings, given 5-ml Bomb ratings of 400°F. These results are summarized in the following tabulation.

	Minex Rating, given 400°F 5-ml Bomb Rating	Minex Rating, given 400°F Coker Rating	Coker Rating, given 400°F 5-ml Bomb Rating
Mean Value, °F	386 ± 21	413 ± 22	389 ± 21
Single (Future) Value, °F	386 ± 108	413 ± 105	389 ± 132

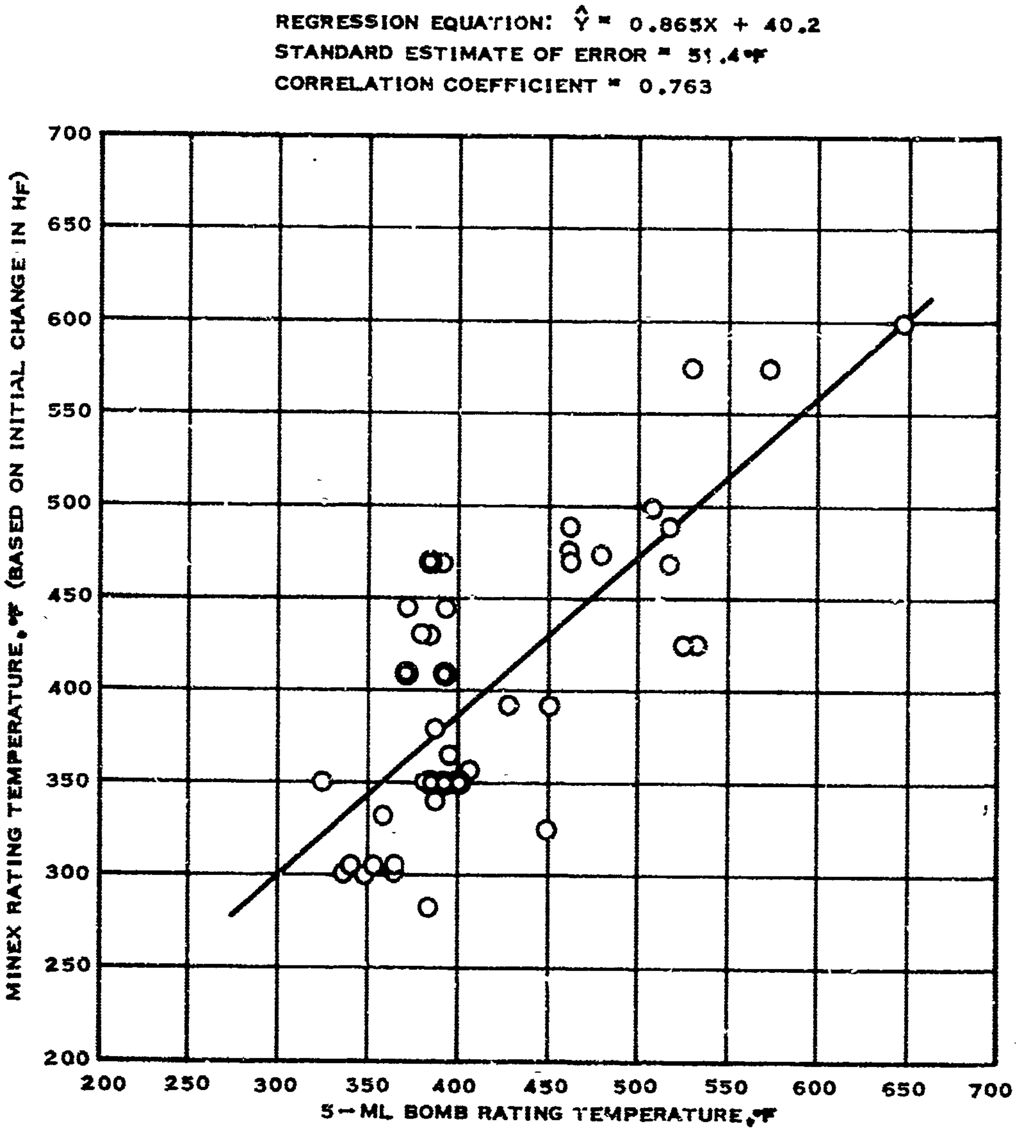

FIGURE 5 RELATIONSHIP BETWEEN 5-ML BOMB AND MINEX RATINGS OF JP FUEL THERMAL STABILITY QUALITY

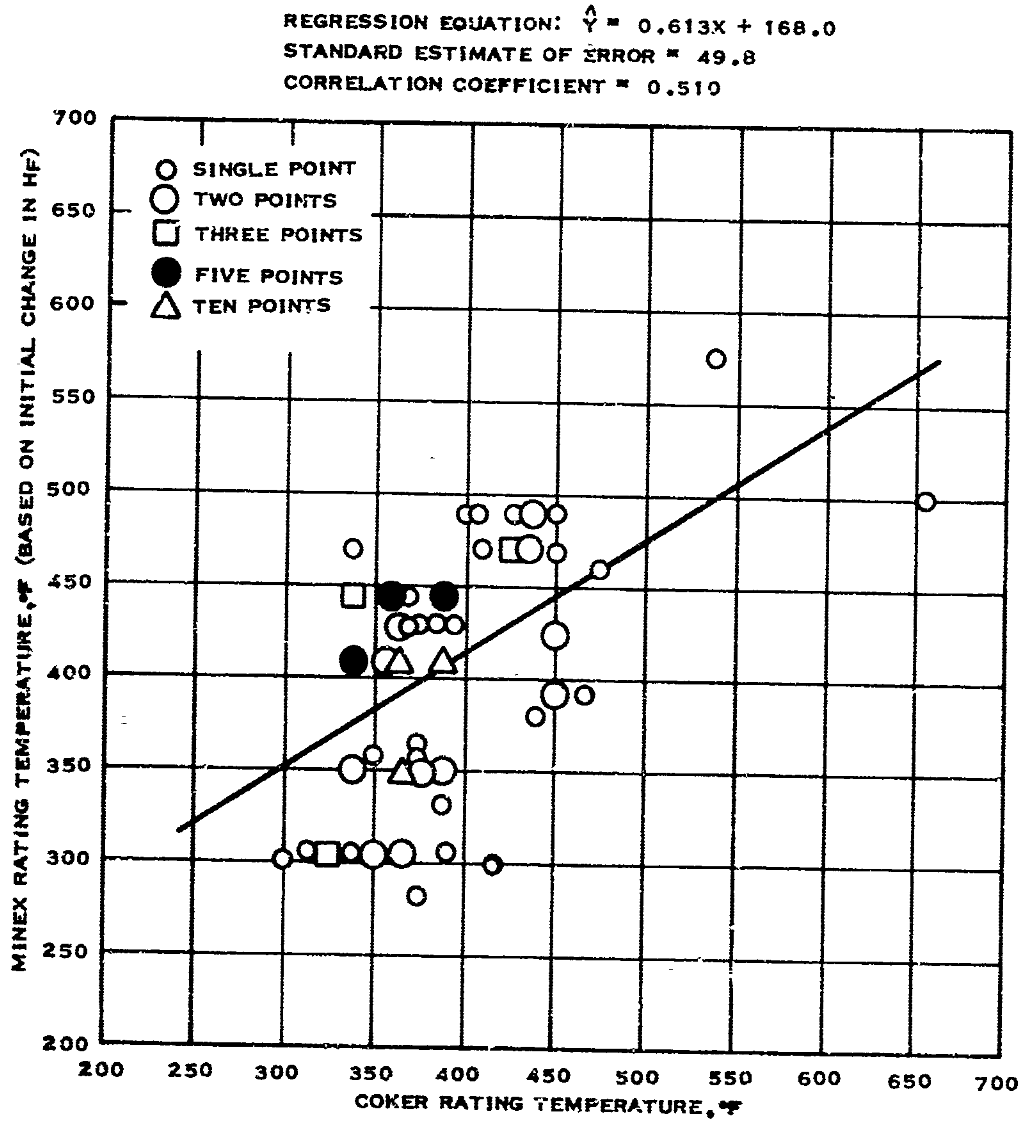

FIGURE 6 RELATIONSHIP BETWEEN COKER AND MINEX RATINGS OF JP FUEL THERMAL STABILITY QUALITY

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REGRESSION EQUATION: $\hat{Y} = 1.137X - 65.9$
STANDARD ESTIMATE OF ERROR = 59.0°F
CORRELATION COEFFICIENT = 0.760

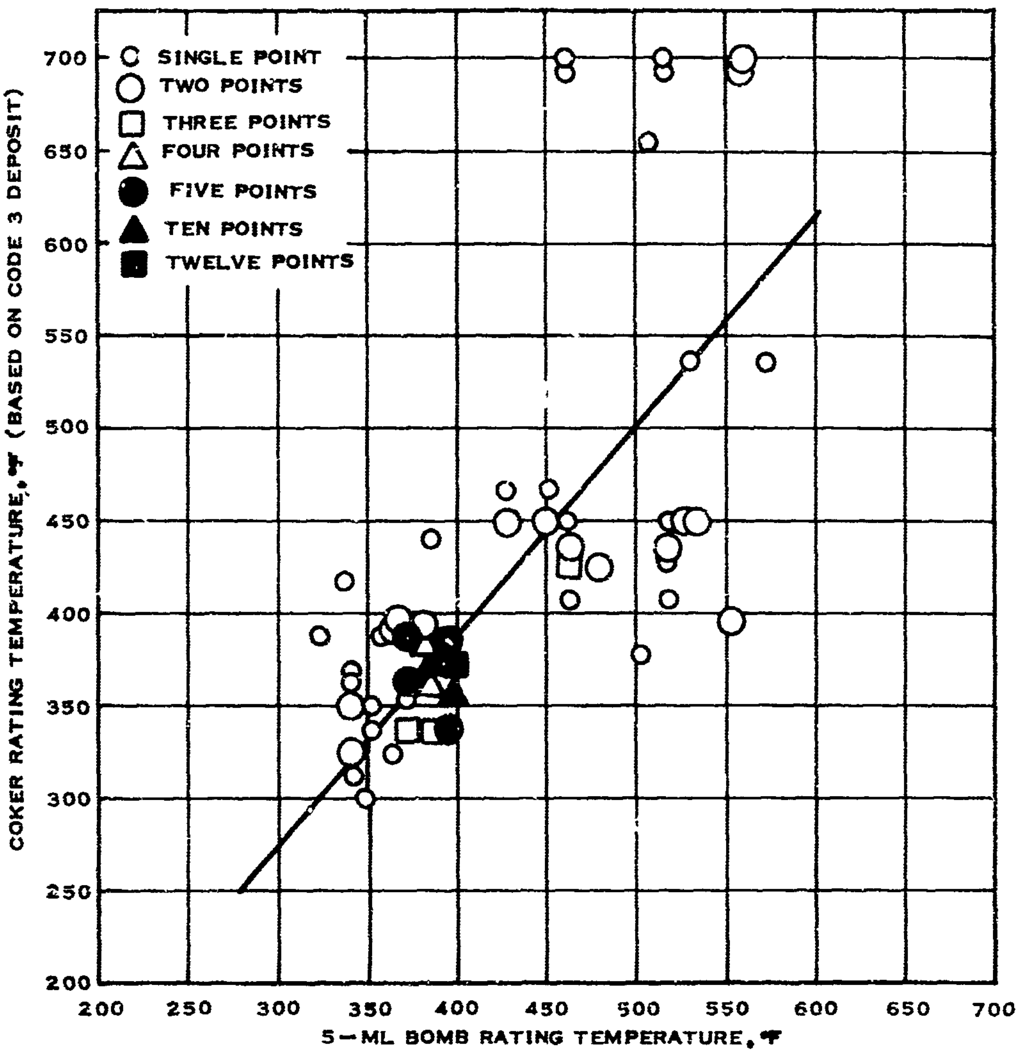

FIGURE 7 RELATIONSHIP BETWEEN 5-ML BOMB AND COKER RATINGS OF JP FUEL THERMAL STABILITY QUALITY

It is of interest that a 95 per cent confidence interval estimate for the slope of the true regression line relating 5-ml Bomb and Minex or Coker ratings includes one. Thus, there may be a linear regression of numerical equality between these ratings, within the range of these data. This is shown in the following tabulation, along with the regression equations for the relationships investigated.

	5-ml Bomb vs. Minex	Coker vs. Minex	5-ml Bomb vs. Coker
Regression Equation	$\hat{Y}=0.865X+40.2$	$\hat{Y}=0.613X+168.0$	$\hat{Y}=1.137X+65.9$
Slope Interval	0.638 to 1.092	0.399 to 0.827	0.960 to 1.314

Also indicated is that the 5-ml Bomb and Minex procedures, and the 5-ml Bomb and Coker procedures, used to obtain these fuel performance ratings are at equal levels of test severity.

E. Source of Errors

The precision with which it has been possible to establish the relationships between the Minex, 5-ml Bomb and Coker ratings of JP fuel thermal stability quality is not impressive; however, this is not surprising in view of the well established repeatability problems encountered in measuring thermal stability quality. For example, as previously reported, the standard deviation with our SSF Coker, under the very carefully controlled conditions of our current JP fuel storage stability study, is $\pm$ 24°F. The standard estimate of error is shown in Figures 5, 6 and 7 for the different relationships investigated, and are summarized in the following tabulation.

	5-ml Bomb vs. Minex	Coker vs. Minex	5-ml Bomb vs. Minex
Standard Estimate of Error, °F	$\pm$ 51.4	$\pm$ 49.8	$\pm$ 59.0

The lack of fit by individual points to the regression lines relating Minex, 5-ml Bomb and Coker ratings results from:

(1) Errors of measurement in fuel performance. The precision of these test methods has not been established, and so the magnitude of this measurement error is unknown.

(2) Contamination of fuel during sampling and handling. This is suspected in sample GE-465, where a large discrepancy in Minex rating is evident when compared with GE-465A, and may be present in others to an unknown extent.

(3) Inequality of response by a given test fuel. It is masked in this study by the above mentioned measurement errors and sample contamination, as well as changes in test methods which occurred during the time period these fuels were rated.

IV. EFFECTS OF CONTAMINANTS ON THERMAL STABILITY QUALITY AS MEASURED BY PHILLIPS 5-ML BOMB PROCEDURE

Experimental data to determine the effects of thirteen different contaminants in one base fuel is now complete. Triplicate 5-ml Bomb determinations on each of these fuels have been made and the data are being analyzed statistically to determine (1) the effect of trace quantities of the contaminants on the thermal stability quality of the base fuel (Storage Fuel 5, West Texas hydrotreated kerosine) and (2) the precision of 5-ml Bomb measurements. All data and results will be shown in the next monthly progress report.

V. MISCELLANEOUS 5-ML BOMB TESTS

Two fuels from Wright-Patterson Air Force Base and eight fuels from General Electric Company were submitted for 5-ml Bomb determinations. These fuels were also used in the correlation studies described above. Detailed 5-ml Bomb data for these fuels are shown in Table 21. Graphical representation of these data are shown in Figures 8 through 17. A description of the fuels and a summary of the threshold failure temperatures is given in Table 5.

TABLE 5

SUMMARY OF MISCELLANEOUS REQUESTS FOR 5-ML BOMB EVALUATIONS

BJ-No.	Description	From	5-ml Bomb TFT, °F
BJ66-10-G1	RAF-167YX-60	WPAFB	649
BJ66-10-G2	RAF-174-63	WPAFB	392
BJ65-10-K73	965-3	G.E.	358
BJ65-10-K74	1165-1	G.E.	450
BJ65-10-K75	1265-1	G.E.	388
BJ65-10-K76	1265-2	G.E.	366
BJ65-10-K77	1265-2A	G.E.	388
BJ66-10-K7	1265-3	G.E.	369
BJ66-10-K8	1265-5	G.E.	381
BJ66-10-K9	166-1	G.E.	382

VI. CONCLUSIONS

In a continuing program to determine the storage stability quality of five ASTM Type-A aviation turbine fuels selected to span a range of thermal stability quality from about 300°F to 700°F as measured by the SSF Coker the following conclusions are drawn:

(1) At 72 weeks all of the storage fuels continue to show no deterioration in ambient field or 40°F storage. Four of the five fuels (Storage Fuels 2, 3, 4 and 5) showed no severe losses in thermal stability quality up to 54 weeks at 130°F or 36 days at 180°F. Storage Fuel 1, an HF Alkylate containing about 2 per cent olefins showed a rapid rate of deterioration of about 100°F within 6 days at 180°F, and a moderate rate of deterioration of about 100°F within 54 weeks at 130°F. The data indicate that there are no

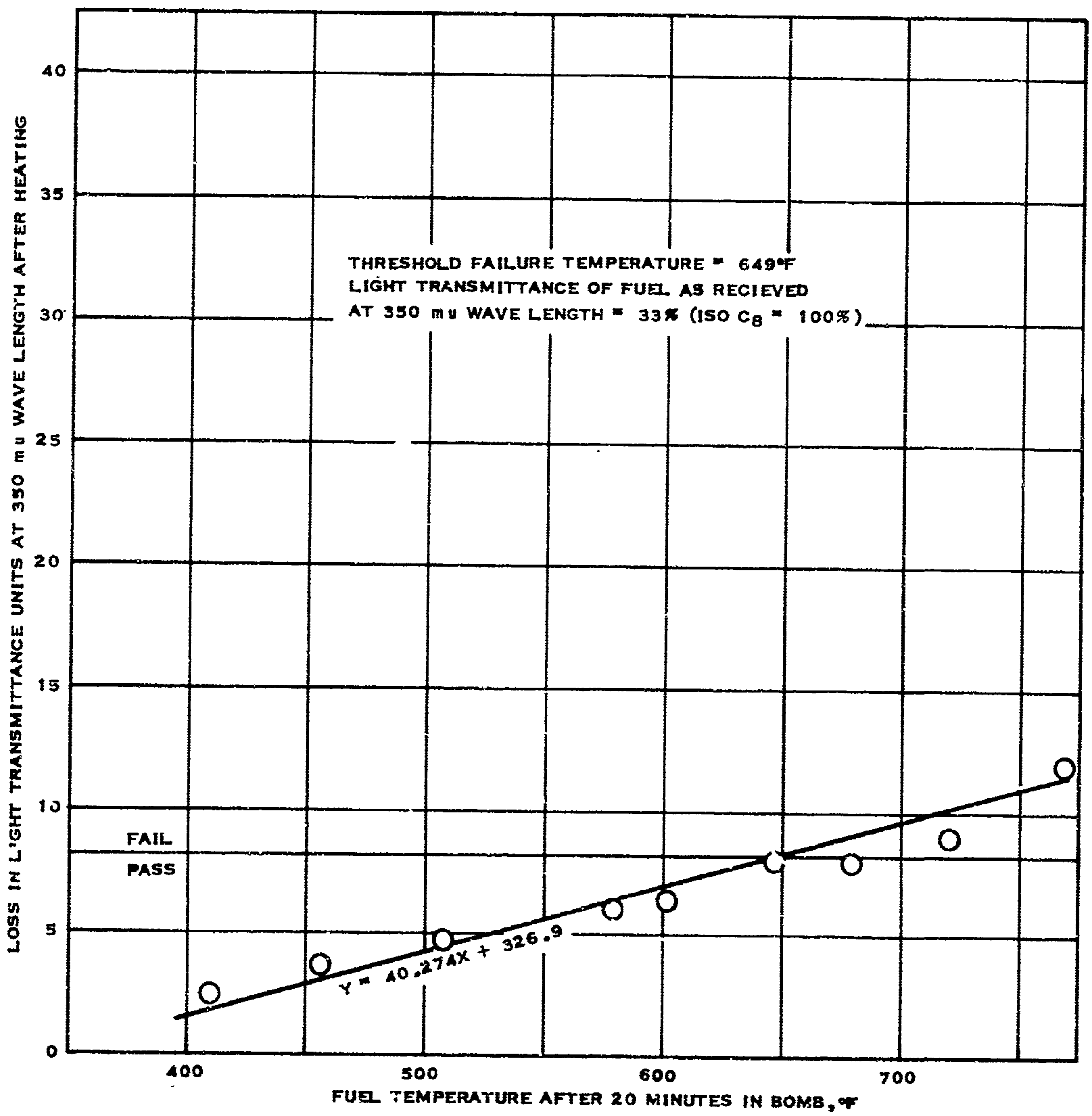

FIGURE 8 PHILLIPS 5-ML BOMB DATA FOR DETERMINATION OF THRESHOLD FAILURE TEMPERATURE OF RAF 167YX-60 (BJ66-10-G1)

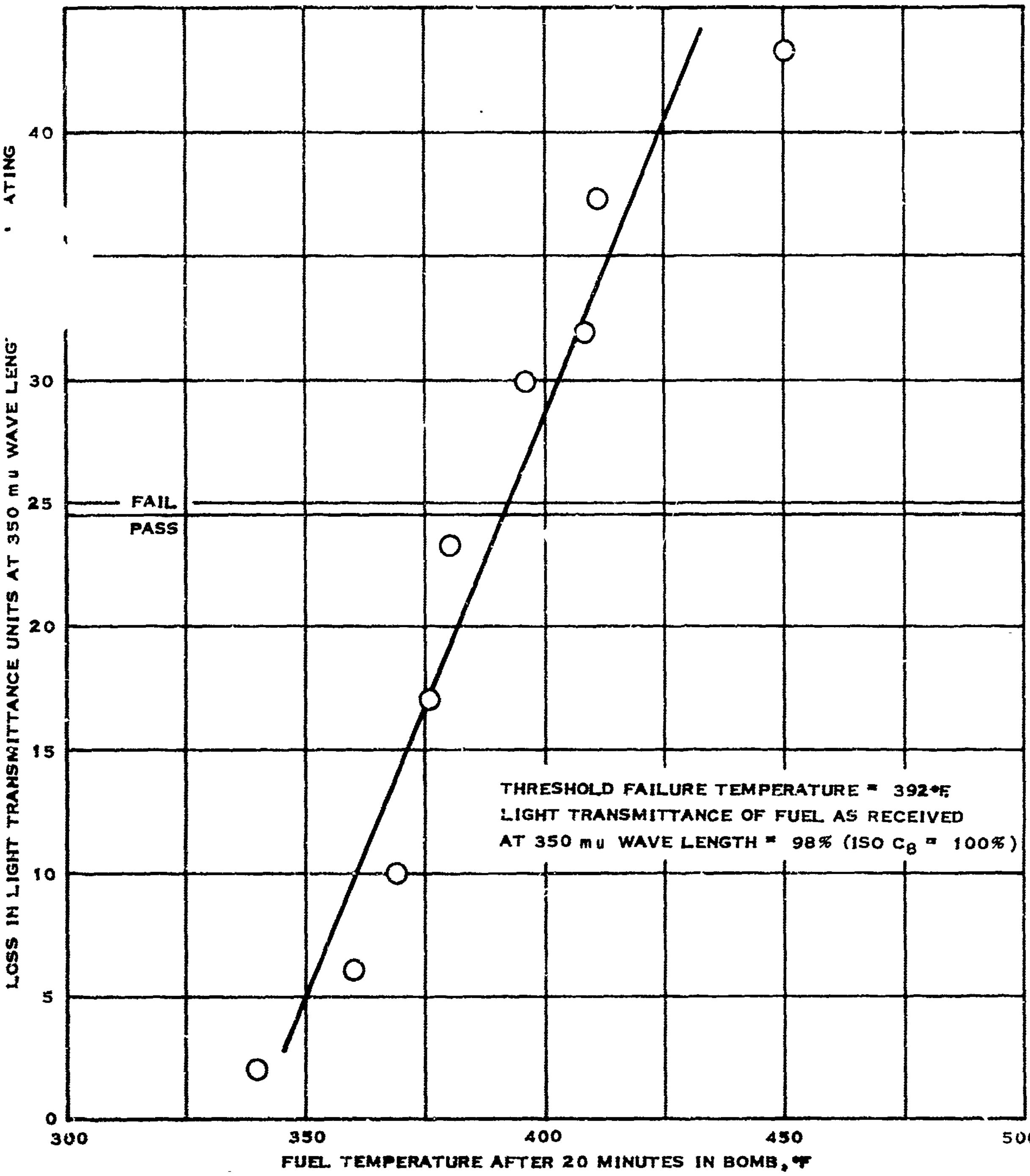

FIGURE 9 PHILLIPS 5-ML BOMB DATA FOR DETERMINATION OF THRESHOLD FAILURE TEMPERATURE OF RAF-174-63 (BJ66-10-62)

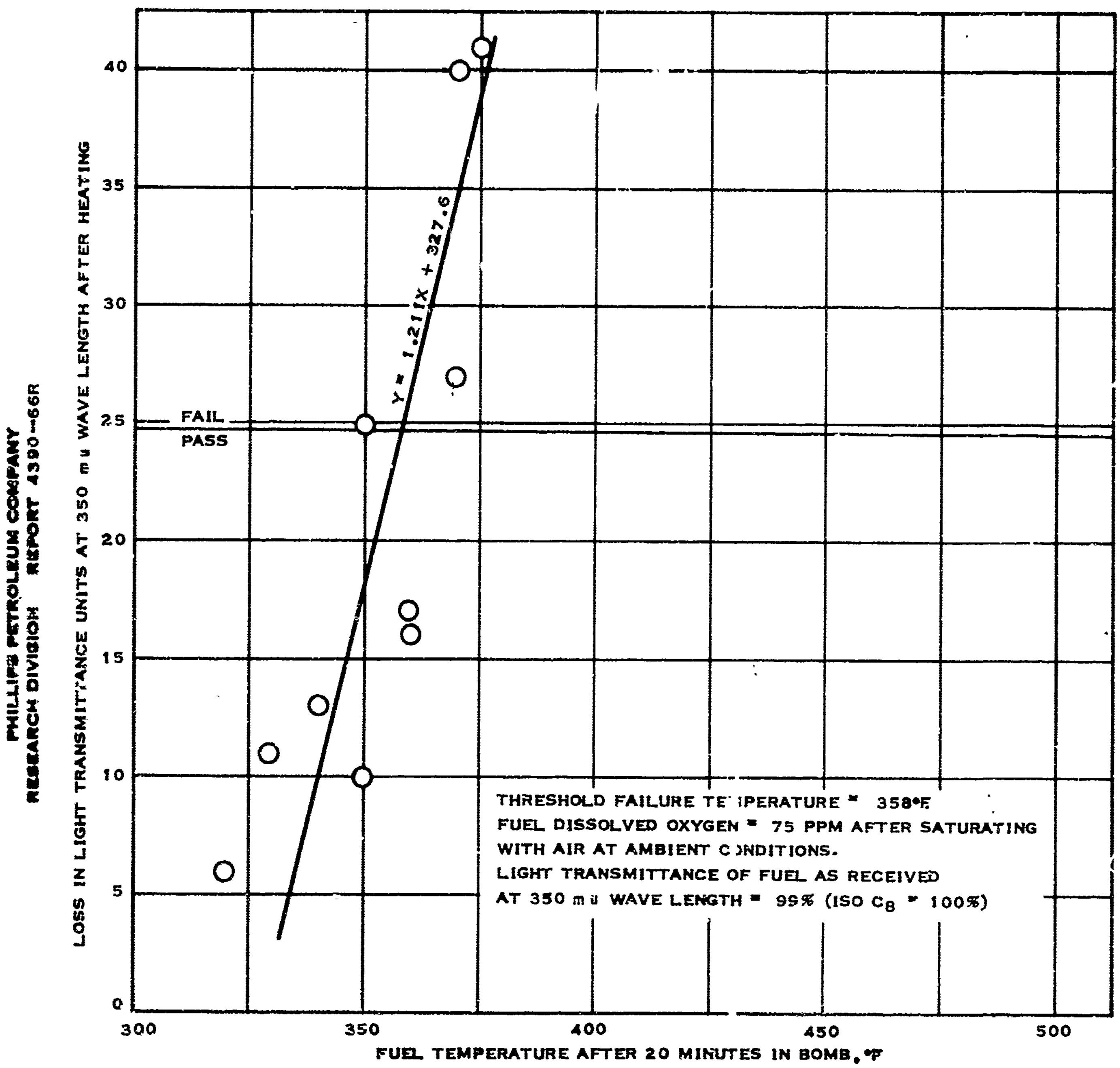

FIGURE 10 PHILLIPS 5-ML BOMB DATA FOR DETERMINATION OF THRESHOLD FAILURE TEMPERATURE OF G. E. FUEL 965-3 (BJ65-10-K73)

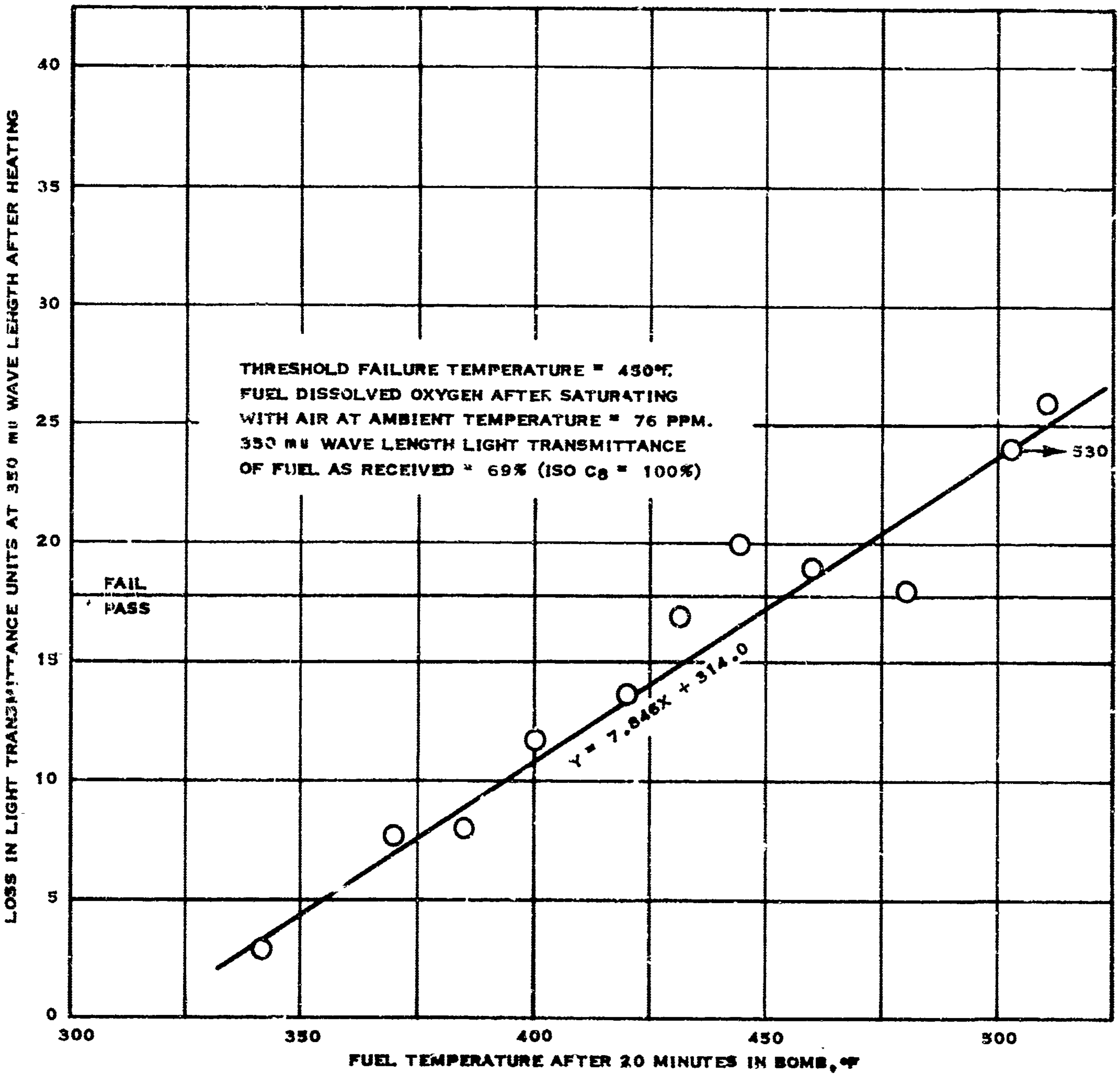

FIGURE 11 PHILLIPS 5-ML BOMB DATA FOR DETERMINATION OF THRESHOLD FAILURE TEMPERATURE OF G. E. FUEL 1165-1 (BJ65-10-K74)

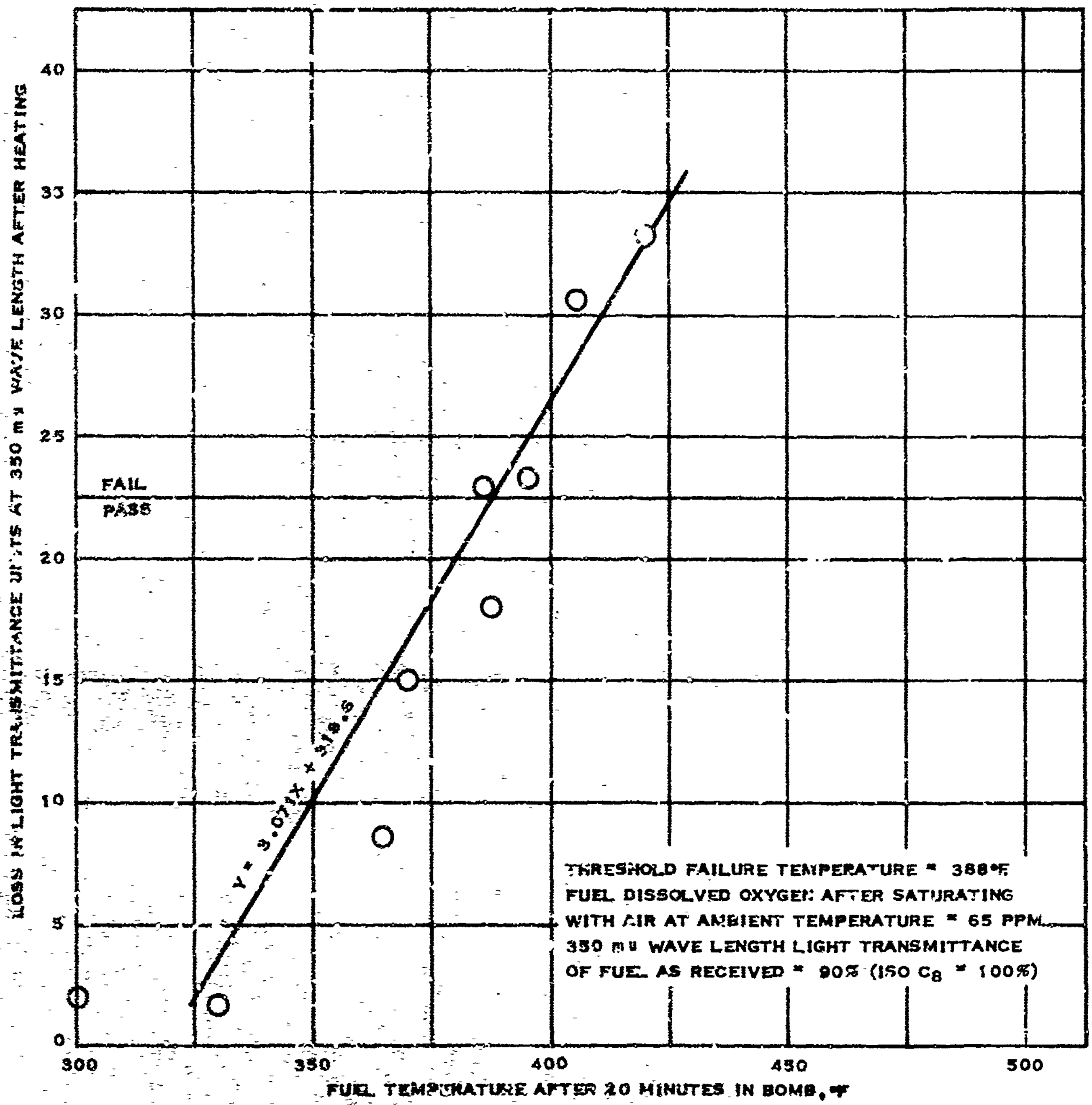

FIGURE 12 PHILLIPS 5-ML BOMB DATA FOR DETERMINATION OF THRESHOLD FAILURE TEMPERATURE OF G. E. FUEL 1265-1 (BJ65-10-K75)

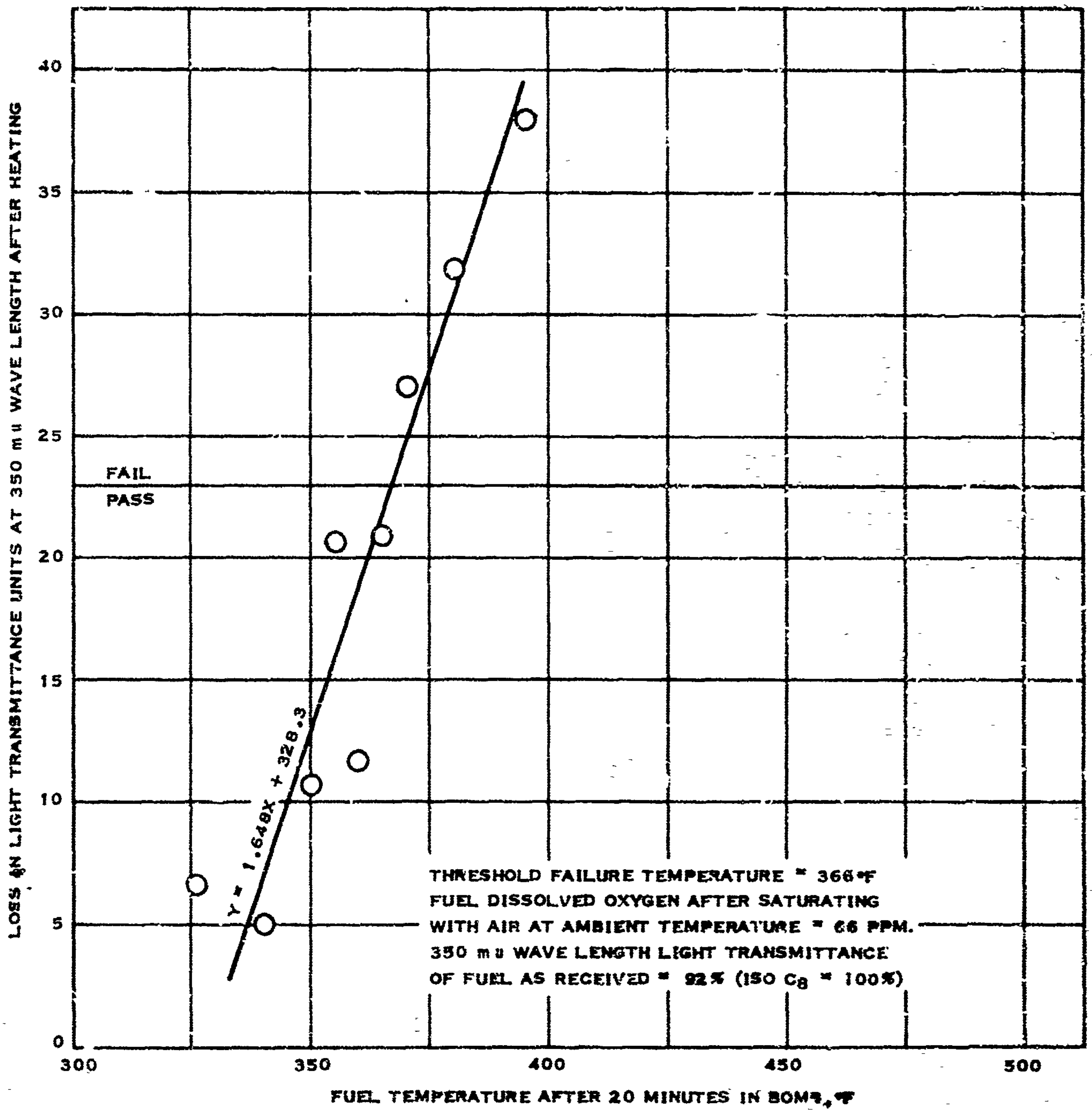

FIGURE 13 PHILLIPS 5-ML BOMB DATA FOR DETERMINATION OF THRESHOLD FAILURE TEMPERATURE OF G. E. FUEL 1265-2 (BJ65-10-K76)

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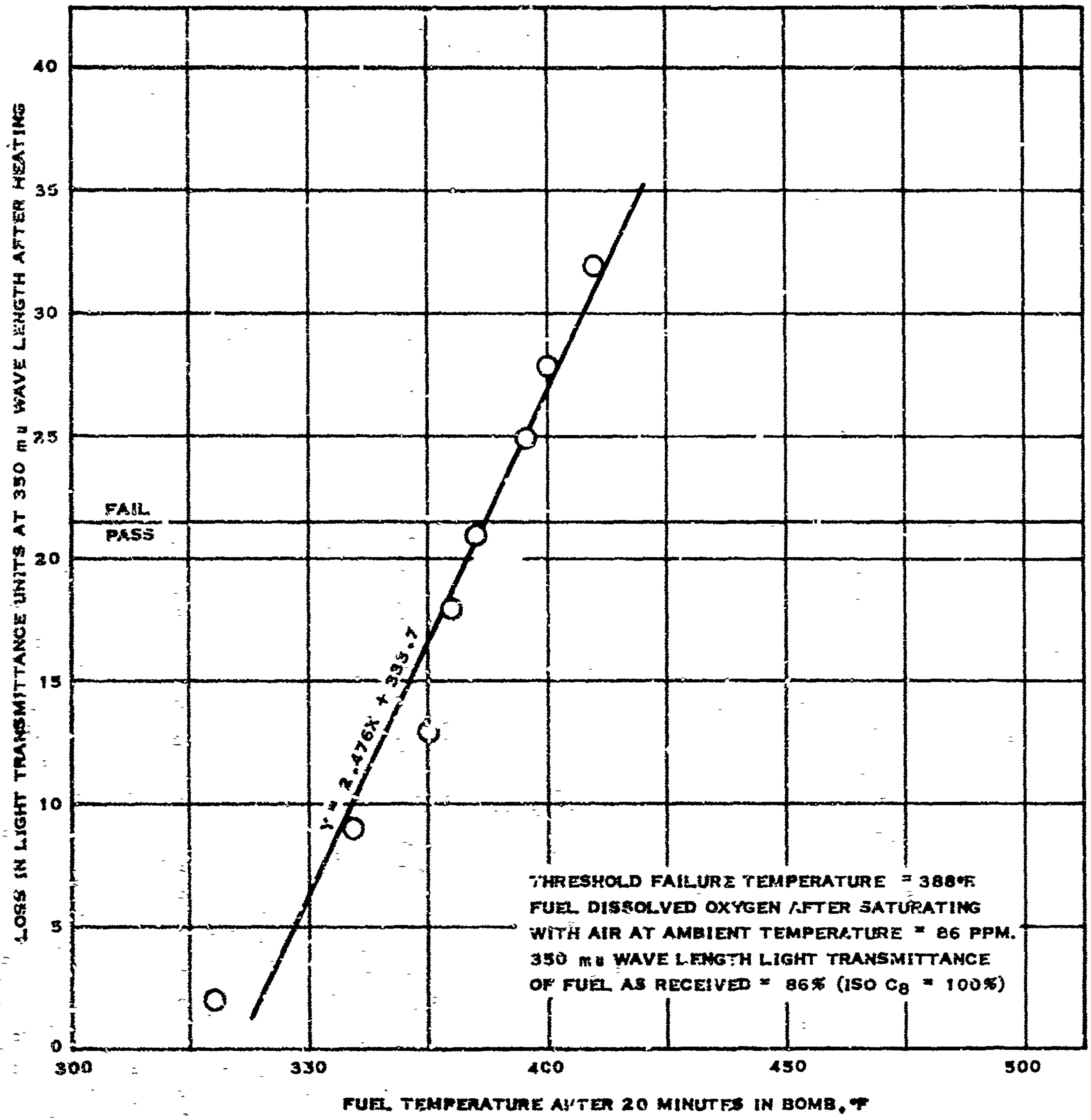

FIGURE 14 PHILLIPS 5-ML BOMB DATA FOR DETERMINATION OF THRESHOLD FAILURE TEMPERATURE OF G. E. FUEL 1265-2A (BJ65-10-K77)

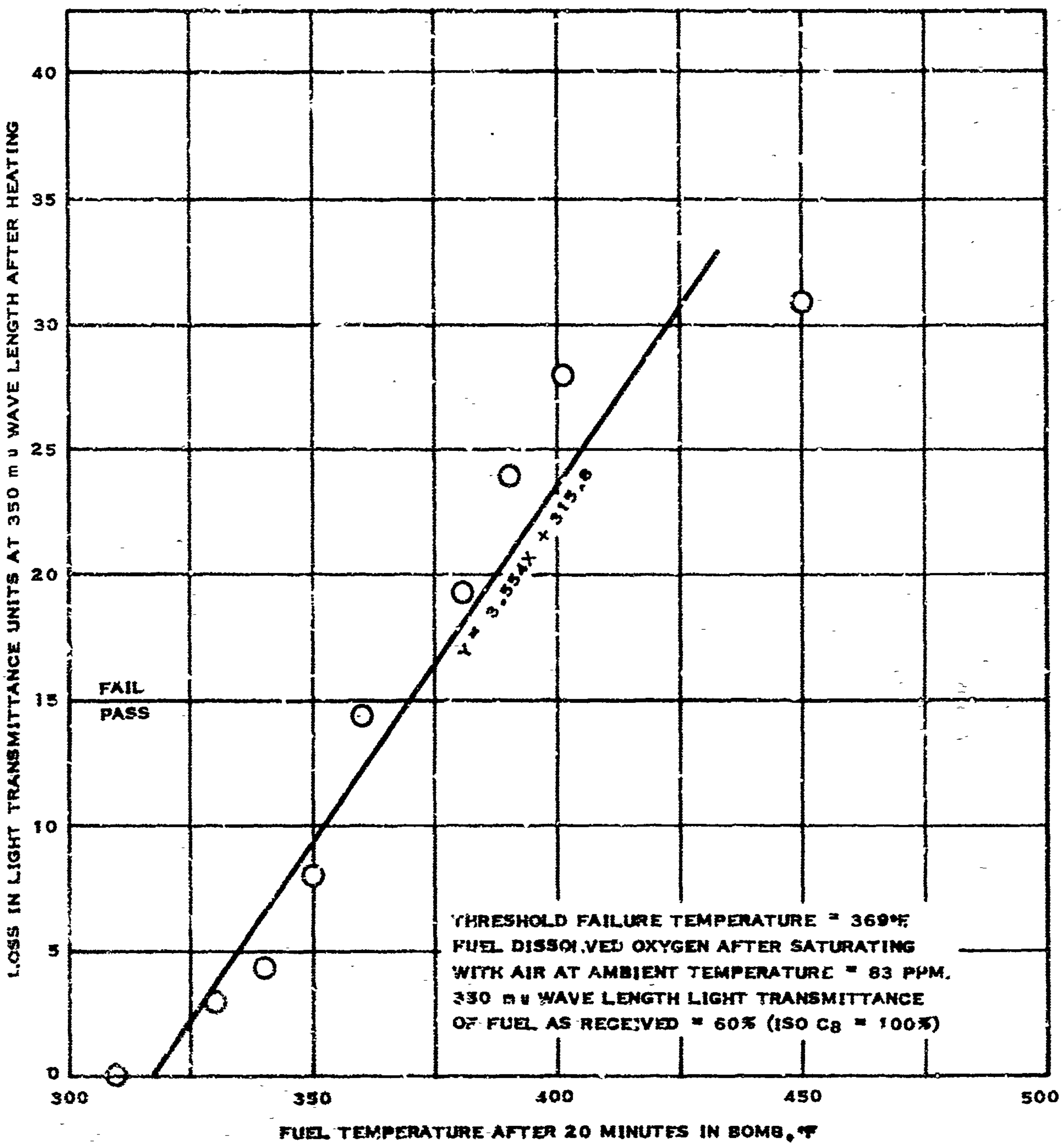

FIGURE 15 PHILLIPS 5-ML BOMB DATA FOR DETERMINATION OF THRESHOLD FAILURE TEMPERATURE OF G. E. FUEL 1265-3 (BJ66-10-K7)

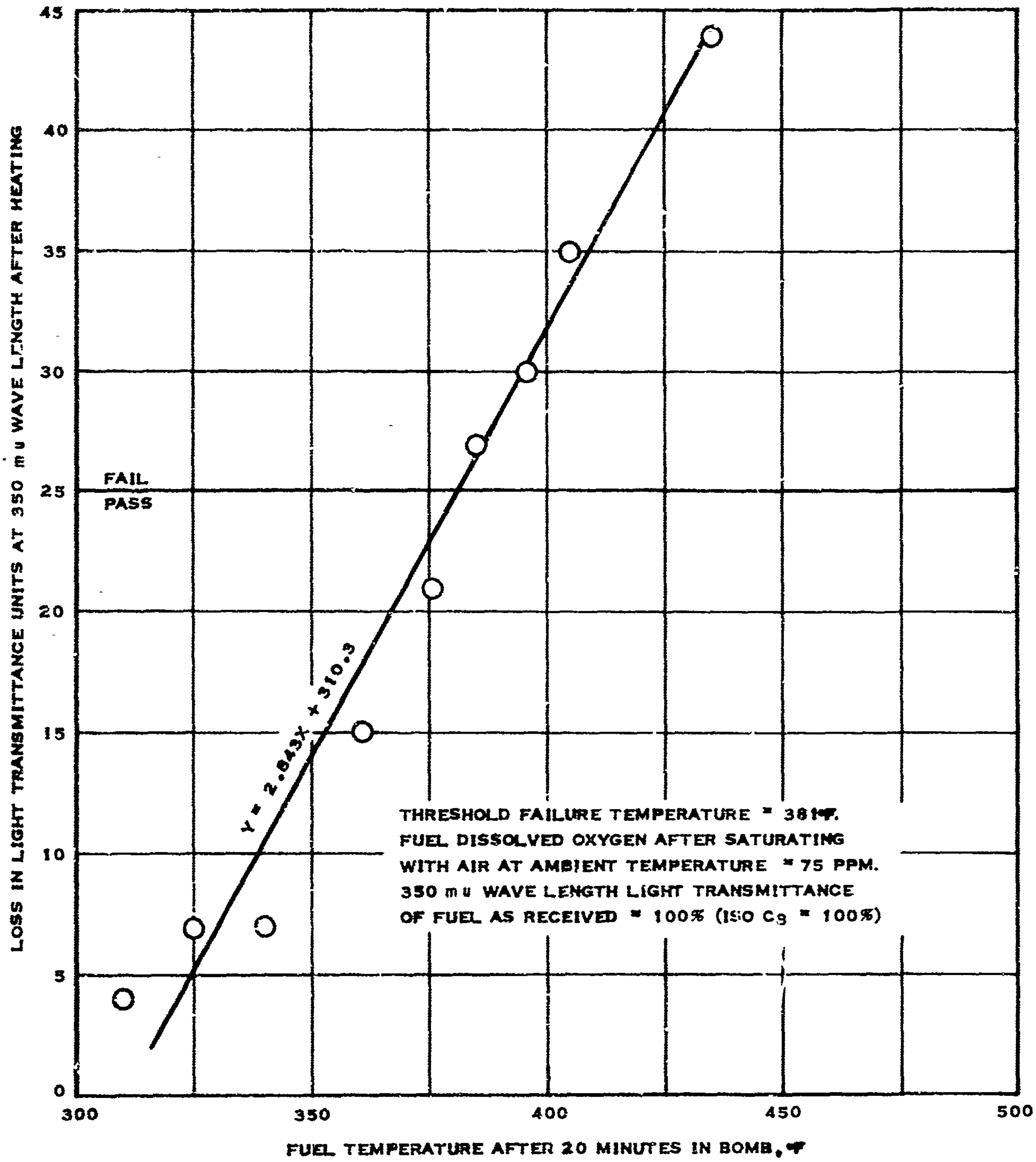

FIGURE 16 PHILLIPS 5-ML BOMB DATA FOR DETERMINATION OF THRESHOLD FAILURE TEMPERATURE OF G. E. FUEL 1265-5 (BJ66-10-K8)

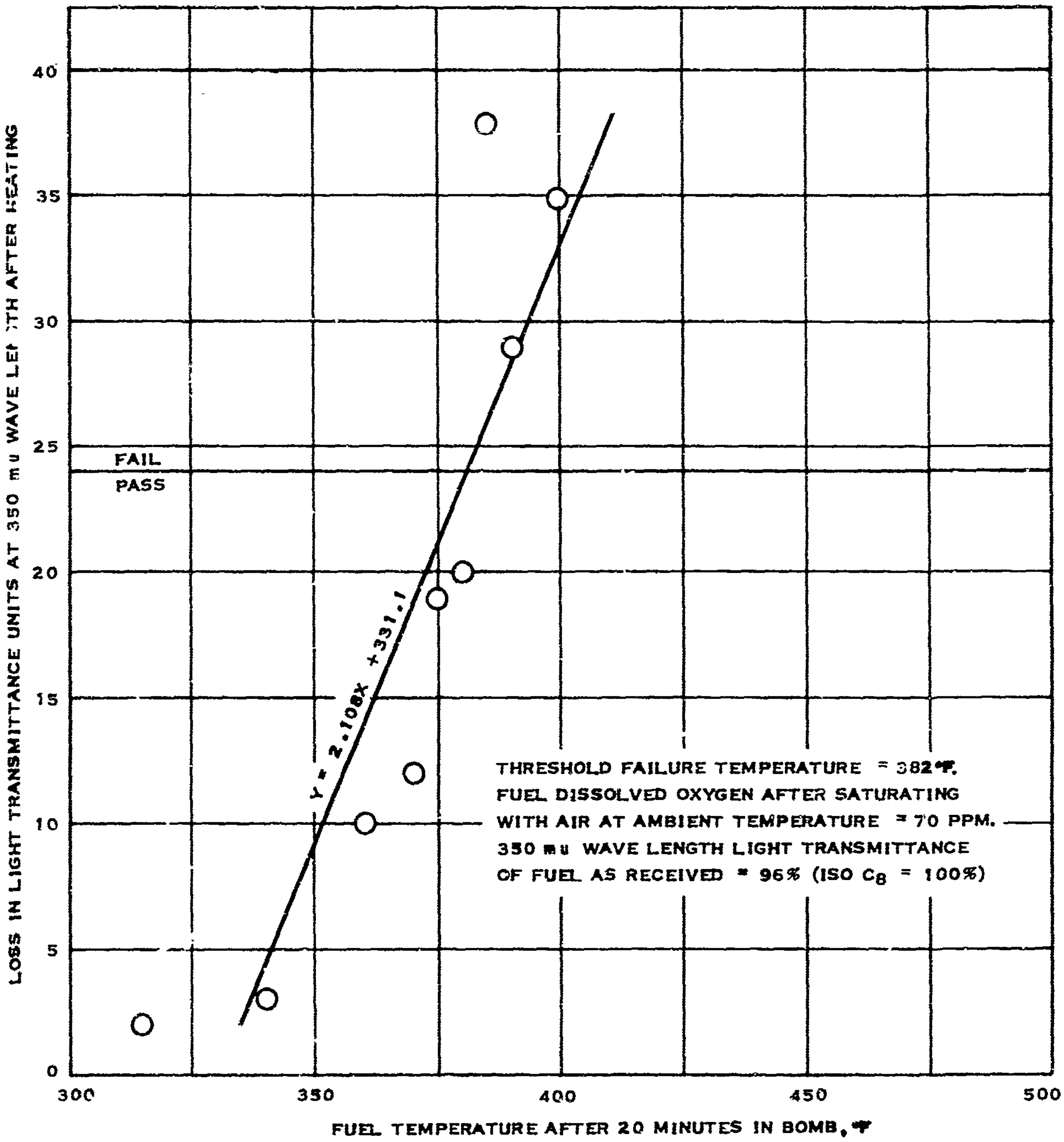

FIGURE 17 PHILLIPS 5-ML BOMB DATA FOR DETERMINATION OF THRESHOLD FAILURE TEMPERATURE OF G. E. FUEL 166-1 (BJ66-10-K9)

storage instability problems at ambient field conditions for the fuels in this study during sealed-drum storage.

(2) Removal of dissolved oxygen (to less than 1 ppm) from the storage fuels of low (350°F) and average (425°F) thermal stability quality continue to show in every case, gross improvements (175-325°F) in thermal stability quality. Only slight improvements (0-50°F) were found for fuels of exceptionally high (625-725°F) thermal stability quality.

(3) Removal of dissolved oxygen (to less than 1 ppm) prior to storage, followed by SSF Coker determinations in the absence of dissolved oxygen, maintained the four stable fuels (Storage Fuels 2, 3, 4 and 5) at exceptionally high thermal stability and prevented deterioration of Storage Fuel 1. This indicates that removal of dissolved oxygen prior to storage results in improved storage stability quality.

Evaluation of the storage stability quality of the fuels in the storage program with Phillips 5-ml Bomb procedure resulted in the following:

(1) An evaluation of the storage stability quality of fuels stored in the absence of dissolved oxygen showed no deterioration of any of the fuels at any of the storage conditions which is in exact agreement with the Coker evaluations of these fuels.

(2) For fuels stored in the aerated state the 5-ml Bomb evaluated 16 out of 20 (five fuels at four different storage temperatures) identically like that of the Coker; 2 of the 20 showed marginally different evaluations; and only 2 of the 20 could be considered major differences in evaluations.

Based upon a statistical analysis of all available Minex evaluations of JP fuel thermal stability quality, and relevant ratings of threshold failure temperature by the 5-ml Bomb and Coker test methods, it is concluded that:

(1) With over 99 per cent confidence, there is a linear thermal relationship between the loss in heat transfer characteristics, as measured by the Minex, and the loss in 350 mμ light transmittance, as measured by the 5-ml Bomb. A similar relationship exists between the formation of colored deposits, as measured by the Coker, and the loss in 350 mμ light transmittance, as measured by the 5-ml Bomb.

(2) A 95 per cent confidence interval estimate of the slope of the true regression line for 5-ml Bomb vs. Minex and 5-ml Bomb vs. Coker ratings indicates that these relationships may be of numerical equality. Thus, given a 5-ml Bomb rating of 400°F, the mean Minex and Coker ratings will be between 365-407 and 368-410°F, respectively. Also, this indicates that the 5-ml Bomb and Minex procedures, and the 5-ml Bomb and Coker procedures, are at equal levels of test severity.

(3) The precision of the 5-ml Bomb test method is probably better than that of either the Minex or the Coker test methods.

VII. RECOMMENDATIONS

Data in this report show with a high degree of confidence that the 5-ml Bomb procedure is related to other thermal stability devices such as the Coker and the Minex procedures. The data also suggest that the precision of the 5-ml Bomb method is equivalent to or better than the Coker method. Finally, 5-ml Bomb data for storage stability evaluations is very similar to Coker evaluations and might be more accurate. It is therefore recommended that the much more economical, and less complex 5-ml Bomb procedure be used for monitoring the storage and thermal stability qualities of JP fuels.

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TABLE 6

SS FUEL COKER DATA AFTER AGING AERATED JET FUELS 100 WEEKS AT 40°F

Fuel Flow Rate: 2.5 Lb/Hr.

Storage Fuel	Run Date	Temperatures °F Pre-heater	Filter	Filter Δ Pressure "Hg	Min.	Preheater Deposit Color Ratings Unwiped	Wiped
No. 1	1-7-66	600	700	0.10	300	0000001112222	0000000112222
	1-10-66	650	750	0.00	300	0000000111441	0000000011331
	1-11-66	625	725	0.00	300	0000001122331	0000001122331
No. 2	1-12-66	350	450	0.10	300	0000000111111	0000000111111
	1-13-66	400	500	25.0	59.84	0000000011444	0000000011444
	1-14-66	375	475	25.0	140.60	0000000001111	0000000001111
No. 3	1-24-66	700	800	0.00	300	0000011112221	0000000111111
	1-25-66	750	850	0.00	300	0000111114153	0000001114152
	1-26-66	725	825	0.00	300	0000111122332	0000011111332
No. 4	1-27-66	700	800	0.00	300	0000011112221	0000000111121
	1-28-66	750	850	0.00	300	0000144545551	0000011125551
	1-31-66	725	825	0.00	300	0000001133322	0000000113322
No. 5	2-15-66	425	525	0.10	300	0000011112222	0000000011111
	2-16-66	475	575	0.00	300	0000000134433	0000000033322
	2-17-66	450	550	0.00	300	0000000012333	0000000001112

TABLE 7

SS FUEL COKER DATA AFTER AGING AERATED JET FUELS 54 WEEKS AT 130°F

Fuel Flow Rate: 2.5 Lb/Hr.

Storage Fuel	Run Date	Temperature, °F Pre-heater	F[illegible]	Filter Δ Pressure [illegible]g	Min.	Preheater Deposit Color Rating Unwiped	Wiped
No. 1	1-17-66	550	650	[illegible].10	300	0000001123544	0000001123544
	1-18-66	500	600	0.10	300	0000000111111	0000000111111
	1-19-66	525	625	0.20	300	0000001112554	0000001112554
No. 2	1-20-66	325	425	2.0	300	0000000011111	0000000001111
	1-21-66	350	450	25.0	174.00	0000000011111	0000000001111
No. 3	12-15-65	700	800	0.00	300	0000001114432	0000001114432
	12-16-65	650	750	5.8	300	0000011111222	0000000111222
	12-17-65	675	775	0.00	300	0000001311221	0000001311221
No. 4	2-1-66	700	800	0.00	300	0000011122222	0000000122222
	2-2-66	750	850	0.00	300	0000111553333	0000001443333
	2-4-66	725	825	0.00	300	0000001144333	00000011[illegible]
No. 5	2-10-66	425	525	0.10	300	0000000112222	0000000011111
	2-11-66	475	575	0.00	300	0000001224433	0000000013233
	2-14-66	450	550	0.00	300	0000000113333	0000000011123

TABLE 8

SS FUEL COKER DATA AFTER AGING AERATED JET FUELS 54 DAYS AT 180°F

Fuel Flow Rate: 2.5 Lb/Hr.

Storage Fuel	Run Date	Temperatures, °F Pre-heater	Filter	Filter Δ Pressure "Hg	Min.	Preheater Deposit Color Ratings Unwiped	Wiped
No. 1	11-10-65	525	625	0.00	300	0000000112444	0000000001111
	11-11-65	475	575	0.10	300	0000000011111	0000000011111
	11-12-65	500	600	0.00	300	0000000111222	0000000111122
	11-15-65	525	625	0.00	300	0000000111444	0000000111222
No. 1	(Dissolved Oxygen Removed After Storage)						
	11-19-65	525	625	0.10	300	0000000144444	0000000111444
No. 2	1-5-66	325	425	1.8	300	0000000011111	0000000011111
	1-6-66	350	450	25.0	291.70	0000000001111	0000000001111
No. 3	(To be determined)						
No. 4	(To be determined)						
No. 5	2-7-66	425	525	0.1	300	0000001111222	0000000111122
	2-8-66	475	575	0.1	300	0000001134443	0000000011113
	2-9-66	450	550	0.2	300	0000000122333	0000000112333

TABLE 9

SSF FUEL COKER DATA AFTER AGING JET FUELS WITH DISSOLVED OXYGEN REMOVED

100 WEEKS AT 40°F

Fuel Flow Rate: 2.5 Lb/Hr.

Storage Fuel	Run Date	Temperature, °F Pre-heater	Temperature, °F Filter	Filter △ Pressure "Hg	Filter △ Pressure Min.	Preheater Deposit Color Ratings Unwiped	Preheater Deposit Color Ratings Wiped
No 5	2-18-66	650	750	0.0	300	0000000112222	0000000112222
	2-21-66	700	800	0.00	300	0000000134433	0000000033322
	2-22-66	675	775	0.00	300	0000000012333	0000000001112

TABLE 10

SS FUEL COKER DATA AFTER AGING JET FUELS WITH DISSOLVED OXYGEN REMOVED

54 WEEKS AT 130°F

Fuel Flow Rate: 2.5 Lb/Hr.

Storage Fuel	Run Date	Temperatures, °F Preheater		Filter Δ Pressure "Hg		Preheater Deposit Color Rating Unwiped	
		Preheater	Filter	"Hg	Min.	Unwiped	Wiped
No. 1	2-23-66	700	800	0.00	300	0000001223333	0000001223333
	2-24-66	650	750	0.00	300	0000001122222	0000000112222
	2-25-66	675	775	0.00	300	0000001112212	0000001112212
No. 2	3-1-66	550	650	0.00	300	0000001212122	0000001111222
	3-2-66	600	700	25.0	108.75	0000003223443	0000000122443
	3-3-66	575	675	0.30	300	0000013311221	0000001311221

TABLE 11

SS FUEL COKER DATA AFTER AGING JET FUELS WITH DISSOLVED OXYGEN REMOVED

54 DAYS AT 180°F

Fuel Flow Rate: 2.5 Lb/Hr.

Storage Fuel	Run Date	Temperatures, °F Pre-heater	Temperatures, °F Filter	Filter Δ Pressure "Hg	Filter Δ Pressure Min.	Preheater Deposit Color Ratings Unwiped	Preheater Deposit Color Ratings Wiped
No. 1	12-9-65	650	750	0.00	300	0000014444221	0000014444221
	12-10-65	600	700	0.00	300	0000000231111	0000000221111
	12-13-65	625	725	0.00	300	0000001223321	0000001223321
	12-14-65	600	700	0.10	300	0000000112222	0000000112222
No. 2	(To be determined)						
No. 3	(To be determined)						
No. 4	(To be determined)						
No. 5	3-4-66	650	750	0.10	300	0000001112222	0000001112222
	3-7-66	700	800	0.00	300	0000001133333	0000001133333
	3-8-66	675	775	0.00	300	0000001122333	0000001122333

TABLE 12

OXYGEN CONSUMPTION THROUGH SSF COKER AFTER AGING AERATED JET FUELS 100 WEEKS AT 40°F

Storage Fuel	Run Date	Filter Temp., °F	Dissolved O_2 Through Coker, ppm Before	After	Δ	Per Cent Consumed
No. 1	1-7-66	700	74.3	11.2	63.1	85.1
	1-11-66	725	76.8	9.6	67.2	87.5
	1-[illegible]-66	750	76.7	9.4	67.3	87.6
No. 2	1-12-66	450	65.8	54.2	11.6	17.6
	1-14-66	475	64.0	56.8	7.2	10.2
	1-13-66	500	67.2	39.6	27.6	41.1
No. 3	1-[illegible]-66	800	54.0	5.7	48.3	89.5
	1-2[illegible]-66	825	47.0	4.6	42.4	90.3
	1-25-66	850	50.7	4.9	45.8	90.5
No. 4	1-27-66	800	60.2	7.5	2.7	87.8
	1-31-66	825	67.5	7.3	60.2	89.3
	1-28-66	850	65.7	7.9	57.8	88.0
No. 5	2-15-66	525	60.8	10.9	49.9	82.1
	2-17-66	550	58.5	10.2	48.3	82.6
	2-16-66	575	61.0	10.6	50.4	82.5

TABLE 13

OXYGEN CONSUMPTION THROUGH SSF COKER AFTER AGING AERATED JET FUELS 54 WEEKS AT 130°F

Storage Fuel	Run Date	Filter Temp., °F	Dissolved O_2 Through Coker, ppm Before	After	△	Per Cent Consumed
No. 1	1-18-66	600	79.6	11.6	68.0	85.4
	1-19-66	625	82.4	11.2	71.2	86.4
	1-17-66	650	84.3	4.9	79.4	94.2
No. 2	1-20-66	425	67.1	61.2	5.9	87.9
	1-21-66	450	61.8	44.9	16.9	27.3
No. 3	12-17-65	700	39.7	4.0	35.7	89.9
	12-16-65	750	46.2	5.4	40.8	88.3
	12-15-65	800	45.2	4.7	39.5	87.4
No. 4	2-1-66	800	64.0	8.1	55.9	87.3
	2-4-66	825	63.3	7.7	55.6	87.8
	2-2-66	850	60.4	7.3	53.1	87.9
No. 5	2-10-66	525	59.4	10.0	49.4	83.2
	2-14-66	550	59.4	9.2	50.2	84.5
	2-11-66	575	61.4	9.5	51.9	84.5

TABLE 14

OXYGEN CONSUMPTION THROUGH SSF COKER AFTER AGING AERATED JET FUELS

54 DAYS AT 180°F

Storage Fuel	Run Date	Filter Temp., °F	Dissolved O_2 Through Coker, ppm Before	After	Δ	Per Cent Consumed
No. 1	11-11-65	575	70.5	3.8	66.7	94.6
	11-12-65	600	70.0	4.0	66.0	94.3
	11-10-65	625	64.3	4.2	60.1	93.5
	11-15-65	625	68.3	3.6	64.7	94.7
No. 1	(Dissolved Oxygen Removed After Aging)					
	11-19-65	625	<1	—	—	—
No. 2	1-5-66	425	68.9	58.3	10.6	15.4
	1-6-66	450	70.0	47.8	22.2	31.7
No. 3	(To be determined)					
No. 4	(To be determined)					
No. 5	2-7-66	525	61.3	9.2	52.1	85.1
	2-9-66	550	62.5	9.3	53.2	85.1
	2-8-66	575	56.3	9.5	46.8	84.8

TABLE 15

OXYGEN CONSUMPTION THROUGH SSF COKER AFTER AGING JET FUELS WITH DISSOLVED OXYGEN REMOVED 100 WEEKS AT 40°F

Storage Fuel	Run Date	Filter Temp., °F	Dissolved O_2 Through Coker, ppm Before	After	Δ	Per Cent Consumed
No. 5	2-18-66	750	0.7	--	--	--
	2-22-66	775	0.7	--	--	--
	2-21-66	800	0.7	--	--	--

TABLE 16

OXYGEN CONSUMPTION THROUGH SSF COKER AFTER AGING JET FUELS WITH DISSOLVED OXYGEN REMOVED 54 WEEKS AT 130°F

Storage Fuel	Run Date	Filter Temp., °F	Dissolved O_2 Through Coker, ppm			
			Before	After	Δ	Per Cent Consumed
No. 1	2-24-66	750	0.8	--	--	--
	2-25-66	775	0.5	--	--	--
	2-23-66	800	1.0	--	--	--
No. 2	3-1-66	650	0.7	--	--	--
	3-3-66	675	0.7	--	--	--
	3-2-66	700	0.5	--	--	--

TABLE 17

OXYGEN CONSUMPTION THROUGH SSF COKER AFTER AGING JET FUELS WITH DISSOLVED OXYGEN REMOVED 54 DAYS AT 180°F

Storage Fuel	Run Date	Filter Temp., °F	Dissolved O_2 Through Coker, ppm			
			Before	After	Δ	Per Cent Consumed
No. 1	12-10-65	700	0.2	--	--	--
	12-14-65	700	0.2	--	--	--
	12-13-65	725	0.2	--	--	--
	12-9-65	750	0.3	--	--	--
No. 2	(To be determined)					
No. 3	(To be determined)					
No. 4	(To be determined)					
No. 5	3-4-66	750	0.7	--	--	--
	3-8-66	775	0.6	--	--	--
	3-7-66	800	0.5	--	--	--

TABLE 18

5-ML BOMB DATA FOR AERATED FUELS IN STORAGE PROGRAM

Storage Fuel	BJ-No.	Log No.	Run Date	Temp., °F (Y)	Light Transmittance At 350 Millimicrons Before	After	Loss (X)	Regression Data	
Aged 100 Weeks at 40°F (Aerated)									
1	64-10-B33	390	2-14-66	455	66.0	56.0	10.0	$\hat{Y} = 18.150X + 275.0$	(a)
				507		53.0	13.0	S.E.E. = 14.6	(b)
				567		51.0	15.0	$TFT_1 = 728°F$	(c)
				370		60.0	6.0	$TFT_2 = 574°F$	(d)
				301		65.0	1.0		
				601		48.0	18.0		
				643		45.6	20.4		
				695		44.0	22.0		
				767		38.0	28.0		
2	64-10-G64	348	1-14-66	372	99.0	78.6	20.4	$\hat{Y} = 1.319X + 339.5$	(a)
				405		50.3	48.7	S.E.E. = 3.9	(b)
				395		55.5	43.5	$TFT_1 = 372°F$	(c)
				347		93.2	5.8	$TFT_2 = 372°F$	(d)
				385		62.3	36.7		
				340		95.2	3.8		
				361		85.0	14.0		
3	64-10-G96	379	2-4-66	490	97.0	75.0	22.0	$\hat{Y} = 7.222X + 323.0$	(a)
				300		97.0	0.0	S.E.E. = 14.8	(b)
				350		97.0	0.0	$TFT_1 = 504°F$	(c)
				450		78.0	19.0	$TFT_2 = 499°F$	(d)
				405		85.0	12.0		
				380		89.0	8.0		
				580		61.0	36.0		
				534		69.0	28.0		
				560		64.0	33.0		

(See explanation of footnotes at end of table.)

TABLE 18 (Continued)

Storage Fuel	BJ-No.	Log No.	Run Date	Temp. °F (Y)	Light Transmittance At 350 Millimicrons Before	After	Loss (X)	Regression Data	
Aged 100 Weeks at 40°F (Aerated)									
4	64-10-G132	377	2-3-66	432	96.0	83.0	13.0	$\hat{Y} = 9.748X + 317.4$	(a)
				510		77.6	18.4	S.E.E. = 16.1	(b)
				383		90.0	6.0	TFT_1 = 561°F	(c)
				474		79.6	16.4	TFT_2 = 551°F	(d)
				570		69.0	27.0		
				550		70.0	26.0		
				599		67.0	29.0		
				620		68.0	28.0		
				530		74.0	22.0		
5	(To be determined)								
Aged 54 Weeks at 130°F (Aerated)									
1	64-10-B23	353	1-18-66	417	54.0	36.0	18.0	$\hat{Y} = 10.446X + 272.4$	(a)
				522		33.0	21.0	S.E.E. = 20.6	(b)
				374		44.0	10.0	TFT_1 = 534°F	(c)
				306		51.0	3.0	TFT_2 = 413°F	(d)
				350		47.0	7.0		
				390		43.0	11.0		
				410		40.6	13.4		
				450		38.0	16.0		
				480		34.0	20.0		

(See explanation of footnotes at end of table)

TABLE 18 (Continued)

Storage Fuel	BJ-No.	Log No.	Run Date	Temp., °F (Y)	Light Transmittance At 350 Millimicrons: Before	After	Loss (X)	Regression Data	
Aged 54 Weeks at 130°F (Aerated)									
2	64-10-G58	373	2-1-66	359	63.0	51.0	12.0	$\hat{Y} = 4.265X + 291.3$	(a)
				286		60.0	3.0	S.E.E. = 17.3	(b)
				454		30.3	32.7	TFT_1 = 398°F	(c)
				320		55.0	8.0	TFT_2 = 358°F	(d)
				410		34.0	29.0		
				382		45.0	18.0		
				400		34.3	28.7		
				340		53.0	10.0		
				390		33.6	29.4		
				370		46.6	16.4		
3	64-10-G	393	2-16-66	456	98.0	70.0	28.0	$\hat{Y} = 7.426X + 294.5$	(a)
				311		95.0	3.0	S.E.E. = 2.7	(b)
				373		88.0	10.0	TFT_1 = 480°F	(c)
				428		77.0	21.0	TFT_2 = 476°F	(d)
				410		81.0	17.0		
				[illegible]		93.0	5.0		
				482		76.6	21.4		
				505		70.0	28.0		
				552		69.0	29.0		
				600		59.0	39.0		
				470		71.0	27.0		
4	64-10-G125	374	2-2-66	562	98.0	74.0	24.0	$\hat{Y} = 10.266X + 300.0$	(a)
				352		94.0	4.0	S.E.E. = 15.4	(b)
				500		78.0	20.0	TFT_1 = 557°F	(c)
				451		81.6	16.4	TFT_2 = 551°F	(d)
				407		86.0	12.0		
				599		68.0	30.0		
				618		66.0	32.0		
				585		72.0	26.0		
				540		76.0	22.0		

(See explanation of footnotes at end of table.)

TABLE 18 (Continued)

Storage Fuel	BJ-No.	Log No.	Run Date	Temp., °F (Y)	Light Transmittance At 350 Millimicrons Before	After	Loss (X)	Regression Data	
Aged 54 Weeks at 130°F (Aerated)									
5	64-10-G179	385	2-10-66	400	100.0	83.6	16.4	$\hat{Y} = 5.645X + 307.1$	(a)
				350		92.6	7.4	S.E.E. = 9.2	(b)
				450		72.6	27.4	TFT_1 = 448°F	(c)
				375		89.0	11.0	TFT_2 = 447°F	(d)
				425		79.6	20.4		
				475		70.6	29.4		
				500		67.6	32.4		
				525		62.6	37.4		
				440		73.6	26.4		
Aged 54 Weeks at 180°F (Aerated)									
1	64-10-B31	342	1-10-66	367	48.0	44.5	2.5	$\hat{Y} = 16.178X + 263.6$	(a)
				440		37.5	10.5	S.E.E. = 15.7	(b)
				460		34.2	13.8	TFT_1 = 668°F	(c)
				506		33.1	14.8	TFT_2 = 458°F	(d)
				481		34.1	13.9		
				397		40.0	8.0		
				547		31.7	16.3		
				386		40.5	7.5		
2	64-10-G63	392	2-15-66	450	62.0	23.0	39.0	$\hat{Y} = 3.232X + 323.5$	(a)
				305		60.0	2.0	S.E.E. = 15.6	(b)
				370		51.0	11.0	TFT_1 = 404°F	(c)
				425	63.0	32.0	31.0	TFT_2 = 374°F	(d)
				400		37.0	26.0		
				385		48.0	15.0		
				341		57.0	6.0		
				392		49.0	14.0		
				410		32.0	31.0		

(See explanation of footnotes at end of table.)

TABLE 18 (Continued)

Storage Fuel	BJ-No.	Log No.	Run Date	Temp., °F (Y)	Light Transmittance At 350 Millimicrons Before	After	Loss (X)	Regression Data	
Aged 54 Weeks at 180°F (Aerated)									
3	(To be determined)								
4	(To be determined)								
5	64-10-G198	381	2-8-66	385	102.0	92.0	10.0	$\hat{Y} = 7.835X + 296.6$	(a)
				305		99.0	3.0	S.E.E. = 12.2	(b)
				450		82.3	19.7	TFT_1 = 492°F	(c)
				506		78.0	24.0	TFT_2 = 496°F	(d)
				571		67.0	35.0		
				548		70.0	32.0		
				550		71.0	31.0		
				420		87.0	15.0		
				520		72.0	30.0		
Aged 72 Weeks at Ambient Field Conditions (Aerated)									
No. 3	64-10-G73	335	12-16-65	400	98.0	86.0	12.0	$\hat{Y} = 6.588X + 314.6$	(a)
				350		91.6	6.4	S.E.E. = 22.0	(b)
				475		69.6	28.4	TFT_1 = 479°F	(c)
				515		66.0	32.0	TFT_2 = 476°F	(d)
				575		65.3	32.7		
				425		78.6	19.4		
				375		90.6	7.4		
				390		88.0	10.0		
				450		76.0	22.0		

NOTE 1: Linear regression equation not determined since data points are curvilinear. Threshold failure temperatures obtained graphically.

(Y) The dependent variable (Y-axis) in the regression equation.
(X) The independent variable (X-axis) in the regression equation.
(a) Linear regression equation representing experimental data in terms of units loss.
(b) Standard Estimate of Error (Sy.x) of regression data in terms of the dependent variable (°F).
(c) TFT_1 is the predicted temperature based on 25 units loss.
(d) TFT_2 is the predicted temperature based on 25 per cent loss in initial light transmittance at 350 millimicrons wave length.

TABLE 19

5-ML BOMB DATA FOR DISSOLVED-OXYGEN-REMOVED FUELS IN STORAGE PROGRAM

Storage Fuels	BJ-No.	Log No.	Run Date	Temp., °F (Y)	Light Transmittance At 350 Millimicrons Before	After	Loss (X)	Regression Data	
Aged 72 Weeks at Ambient Field Conditions (Dissolved Oxygen Removed)									
1	64-10-B7	346	1-12-66	854	62.0	18.5	43.5	Note 1	
				753		39.5	22.5	TFT_1 = 768°F	(c)
				641		50.0	12.0	TFT_2 = 721°F	(d)
				672		50.5	11.5		
				705		49.3	12.5		
				737		44.5	17.5		
2	64-10-G43	351	1-17-66	678	94.0	92.6	1.4	Note 1	
				690		91.3	2.7	TFT_1 = 883°F	(c)
				790		85.0	9.0	TFT_2 = 882°F	(d)
				900		30.6	63.4		
				825		84.0	10.0		
				860		81.3	12.7		
				875		78.3	15.7		
				885		68.6	25.4		
5	64-10-G174	339	1-5-66	700	101.0	85.6	15.4	Note 1	
				400		96.6	4.4	TFT_1 = 853°F	(c)
				750		85.6	15.4	TFT_2 = 854°F	(d)
				800		85.6	15.4		
				850		78.6	22.4		
				900		22.0	77.0		
				850		76.6	22.4		
				900		19.0	80.0		
Aged 54 Weeks at 180°F (Dissolved Oxygen Removed)									
1	64-10-B32	344	1-11-66	863	65.5	18.2	47.3	Note 1	
				668		53.2	12.3	TFT_1 = 818°F	(c)
				708		49.5	16.0	TFT_2 = 733°F	(d)
				788		45.2	20.3		
				734		48.3	17.2		
				622		58.3	7.2		
				858		17.7	47.8		

(See explanation of footnotes at end of previous table.)

TABLE 20

MINEX DATA FOR CORRELATION WITH PHILLIPS 5-ML BOMB AND COKERS

BJ-Number	Fuel Out Temp., °F	Total Time, Hours Start	End	Δ	"h_f", BTU/(hr)(ft^2)(°F) Start	End	Δ	%Δ	% Loss "h_f" Per Hour	Interpolated Fuel Temp. for Initial Loss in "h_f", °F
BJ62-10-K30 (G.E. Data)	250	(Not Available)			(Not Available)				0	350
	300								0	
	350								0	
	400								1.1	
	450								12.0	
BJ62-10-K31 (G.E. Data)	250	(Not Available)			(Not Available)				0	300
	300								0	
	350								0.4	
	400								1.3	
	450								4.0	
BJ63-10-G74 (G.E. Data)	350	0	25.50	25.50	690	690	0	0	0	350
	380	25.50	46.25	20.75	740	695	45	6.08	0.29	
	395	46.25	52.00	5.75	715	690	25	3.50	0.61	
	350	52.00	74.25	22.25	693	693	0	0	0	
	365	74.25	92.50	18.25	698	690	8	1.15	0.06	
	380	92.50	111.00	18.50	695	675	20	2.88	0.16	
BJ63-10-G74 (A.F. Data)	350	0	17.00	17.00	744	740	4	0.54	0.03	350
	370	20.00	32.50	12.50	720	682	38	5.28	0.42	
	390	32.50	55.00	22.50	672	600	72	10.71	0.48	
	410	55.00	72.50	17.50	580	520	60	10.34	0.59	
	430	72.50	85.50	13.00	510	460	50	9.80	0.75	
	450	86.00	94.00	8.00	424	348	76	17.92	2.24	
	470	94.00	99.00	5.00	348	250	98	28.16	5.63	
	350	99.00	106.00	7.00	310	324	-14	-4.52	-0.65	

TABLE 20 (Continued)

BJ-Number	Fuel Out Temp., °F	Total Time, Hours Start	End	Δ	"h_f", BTU/(hr)(ft^2)(°F) Start	End	Δ	%Δ	% Loss "h_f" Per Hour	Interpolated Fuel Temp. for Initial Loss in "h_f", °F
BJ64-10-G107 (A.F. Data)	350	0	16.50	16.50	700	700	0	0	0	>625
	475	16.50	35.50	19.00	740	740	0	0	0	
	485	35.50	47.00	11.50	708	708	0	0	0	
	500	47.00	64.50	17.50	740	740	0	0	0	
	525	64.50	80.00	16.50	760	760	0	0	0	
	550	80.00	99.50	19.50	764	764	0	0	0	
	575	99.50	112.50	13.00	772	772	0	0	0	
	600	112.50	130.50	18.00	780	780	0	0	0	
	625	130.50	140.00	9.50	780	780	0	0	0	
BJ64-10-G144 (G.E. Data)	325	0	20.50	20.50	570	565	5	0.88	0.04	300
	350	20.50	28.50	8.00	560	510	50	8.93	1.12	
	300	28.50	46.00	17.50	505	490	15	2.97	0.17	
	325	46.00	71.00	25.00	495	415	80	16.16	.65	
	350	71.00	88.25	17.25	405	345	60	14.81	.86	
	375	88.25	102.75	14.50	340	260	80	23.53	1.62	
	400	102.75	108.75	6.00	255	215	40	15.69	2.61	
	425	108.75	115.00	6.25	210	160	50	23.81	3.81	
BJ64-10-G162 (G.E. Data)	300	0	21.75	21.75	675	675	0	0	0	[illegible]
	330	21.75	43.50	21.75	690	690	0	0	0	
	360	43.50	64.50	21.00	705	705	0	0	0	
	390	64.50	82.00	17.50	715	715	0	0	0	
	420	82.00	100.0	18.00	735	735	0	0	0	
	450	101.50	118.50	17.00	747	735	12	1.61	0.09	
	480	118.50	128.00	9.50	760	715	45	5.92	0.62	
	480	128.50	134.50	6.00	715	515	200	27.97	5.00	

TABLE 20 (Continued)

BJ-Number	Fuel Out Temp., °F	Total Time, Hours Start	End	Δ	"h_f" BTU/(hr)(ft^2)(°F) Start	End	Δ	% Δ	% Loss "h_f" Per Hour	Interpolated Fuel Temp. for Initial Loss in "h_f", °F
BJ64-10-F162 (G.E. Data)	300	0	21.50	21.50	665	665	0	0	0	410
	330	21.50	43.50	22.00	695	695	0	0	0	
	360	43.50	64.50	21.00	715	715	0	0	0	
	390	64.50	82.25	17.75	725	725	0	0	0	
	420	82.25	101.50	19.25	755	745	10	1.32	0.07	
	450	101.50	118.50	17.00	760	665	95	12.50	0.74	
	480	119.50	126.50	7.00	650	300	350	53.85	7.69	
BJ64-10-G162 (A.F. Data)	350	0	6	6	785	785	0	0	0	410
	375	6	18	12	810	810	0	0	0	
	400	18	28	10	820	820	0	0	0	
	410	28	40	12	827	827	0	0	0	
	430	40	50	10	830	787	43	5.18	0.52	
	430	50	64	14	790	790	0	0	0	
	450	64	69	5	780	345	435	55.77	11.15	
BJ64-10-G163 (G.E. Data)	350	0	21.50	21.50	775	775	0	0	0	470
	380	21.50	46.50	25.00	745	743	2	0.27	0.01	
	410	46.50	75.00	28.50	735	730	5	0.68	0.02	
	440	75.00	93.50	18.50	728	730	-2	-0.27	-0.01	
	470	93.50	106.50	13.00	730	733	-3	-0.41	-0.06	
	500	106.50	122.00	15.50	750	685	65	8.67	0.56	
BJ64-10-G163 (A.F. Data)	350	0	20	20	798	798	0	0	0	490
	410	20	50	30	762	762	0	0	0	
	450	50	60	10	724	724	0	0	0	
	500	60	71	11	685	672	13	1.90	0.17	
	510	71	81	10	680	546	134	19.71	1.97	

TABLE 20 (Continued)

BJ-Number	Fuel Out Temp., °F	Total Time, Hours Start	End	Δ	"h_f", BTU/(hr)(ft^2)(°F) Start	End	Δ	% Δ	% Loss "h_f" Per Hour	Interpolated Fuel Temp. for Initial Loss 1 "h_f", °F
BJ64-10-G166 (A.F. Data)	350	0	9	9	606	606	0	0	0	475
	375	9	15	6	628	628	0	0	0	
	400	15	22	7	628	628	0	0	0	
	420	22	33	11	632	628	4	0.63	0.06	
	440	33	40	7	632	632	0	0	0	
	475	46	51	5	636	636	0	0	0	
	490	56	65	9	680	616	64	9.41	1.05	
	510	65	71	6	602	560	42	6.98	1.16	
BJ64-10-G234 (A.F. Data)	350	0	15	15	792	792	0	0	0	430
	370	15	36	21	808	808	0	0	0	
	390	36	50	14	820	820	0	0	0	
	410	50	66	16	820	820	0	0	0	
	430	66	74.50	8.50	820	820	0	0	0	
	450	74.50	94.00	19.50	832	760	72	8.65	0.44	
	470	94	110	16	760	668	92	12.11	0.76	
BJ64-10-K26 (G.E. Data)	300	0	22	22	632	614	18	2.85	0.13	305
	325	23	42	19	622	576	46	7.40	0.39	
	350	43	64	21	615	590	25	4.07	0.19	
	400	65	84	19	616	602	14	2.27	0.12	
	450	85	90	5	582	484	98	16.84	3.37	
	350	1	18	17	633	598	35	5.53	0.33	
	450	18	24.50	6.50	577	430	147	25.48	3.92	
	350	1	15	14	612	590	22	3.59	0.26	
	450	16	22	6	616	492	124	20.13	3.36	
	350	1	20	19	584	564	20	3.42	0.18	
	450	20	27	7	534	416	118	22.10	3.16	
BJ64-10-K148 (A.F. Data)	400	0	15	15	704	704	0	0	0	575
	450	15	28	13	704	704	0	0	0	
	500	28	55	27	686	686	0	0	0	
	525	55	85	30	690	690	0	0	0	
	550	85	102.25	17.25	680	680	0	0	0	
	575	102.25	120	17.75	680	680	0	0	0	
	600	120	138	18	722	468	254	35.18	1.95	

TABLE 20 (Continued)

BJ-Number	Fuel Out Temp., °F	Total Time, Hours Start	End	Δ	"h_f", BTU/(hr)(ft^2)(°F) Start	End	Δ	% Δ	% Loss "h_f" Per Hour	Interpolated Fuel Temp. for Initial Loss in "h_f", °F
BJ64-10-L200 (G.E. Data)	450	0	11.50	11.50	717	717	0	0	0	500
	500	11.50	30.50	19.00	700	700	0	0	0	
	540	30.50	61.75	31.25	668	640	28	4.19	0.3	
	560	61.75	76.50	14.75	680	655	25	3.68	0.25	
	580	76.50	83.00	6.50	665	645	20	3.01	0.46	
BJ65-10-G46 (G.E. Data)	275	0	20	20	560	564	-4	-0.71	0.04	284
	300	20	43	23	580	568	12	2.07	0.09	
	325	43	62.50	19.50	588	540	48	8.16	0.42	
	350	62.50	79	16.50	540	468	72	13.33	0.81	
	375	79	91	12	472	388	84	17.80	1.48	
BJ65-10-G46A (G.E. Data)	300	0	19.75	19.75	586	586	0	0	0	365
	325	27.50	55.50	28.00	632	632	0	0	0	
	350	55.50	75.75	20.25	628	628	0	0	0	
	375	96	108	12	628	620	8	1.27	0.11	
BJ65-10-K25 (G.E. Data)	350	(Not Available)							-0.57	393
	380								-0.30	
	405								0.70	
	425								1.42	
	445								8.20	
BJ65-10-K27 (G.E. Data)	350	(Not Available)							-0.40	425
	380								0.50	
	405								1.40	
	425								0	
	445								1.30	
	475								2.60	
	505								4.30	

TABLE 20 (Continued)

BJ-Number	Fuel Out Temp., °F	Total Time, Hours Start	End	Δ	"h_f", BTU/(hr)(ft^2)(°F) Start	End	Δ	% Δ	% Loss "h_f" Per Hour	Interpolated Fuel Temp. for Initial Loss in "h_f", °F
BJ65-10-K62 (G.E. Data)	300	0	25.50	25.50	560	570	-10	-1.79	-0.07	>400
	325	25.50	43.30	17.80	580	588	-8	-1.38	-0.08	
	400	48.50	79.00	30.50	608	620	-12	-1.97	-0.06	
BJ65-10-K71 (A.F. Data)	350	0	6	6	634	632	2	.32	0.05	470
	400	6	12	6	635	635	0	0	0	
	425	12	18	6	635	635	0	0	0	
	440	18	29	11	630	630	0	0	0	
	450	29	35	6	626	628	-2	-.32	-0.05	
	460	35	41	6	630	630	0	0	0	
	470	41	47	6	618	618	0	0	0	
	480	51	59	8	612	570	42	6.86	0.86	
	490	59	65	6	550	310	240	43.64	7.27	
BJ65-10-K72 (G.E. Data)	325	0	12	12	649	676	27	- 4.16	-0.35	356
	400	12.50	27.50	15	676	626	50	7.40	0.49	
BJ65-10-K73 (G.E. Data)	300	0	12	12	562	562	0	0	0	332
	325	12	30	18	572	572	0	0	0	
	350	30	48.50	18.50	586	566	20	3.41	0.18	
	400	48.50	70.50	22	594	594	0	0	0	
BJ65-10-K74 (G.E. Data)	325	0	12	12	565	565	0	0	0	325
	350	12	25	13	570	552	18	3.16	0.24	
	400	25	42.50	17.50	582	528	54	9.30	0.53	
BJ65-10-K75 (G.E. Data)	325	0	13.50	13.50	556	568	-12	-2.16	-0.16	340
	350	13.50	28.75	15.25	574	560	14	2.44	0.16	
	400	28.75	43.00	14.25	580	524	56	9.66	0.68	
BJ65-10-K76 (G.E. Data)	325	0	14.50	14.50	668	632	36	5.39	0.37	306
	350	14.50	28.25	13.75	657	636	21	3.20	0.23	

TABLE 20 (Continued)

BJ-Number	Fuel Out Temp., °F	Total Time, Hours Start	End	Δ	"h_f", BTU/(hr)(ft^2)(°F) Start	End	Δ	% Δ	% Loss "h_f" Per Hour	Interpolated Fuel Temp. for Initial Loss in "h_f", °F
BJ65-10-K77	325	0	10	10	676	676	0	0	0	380
(G.E. Data)	350	15	21.25	6.25	652	652	0	0	0	
	400	21.25	30.00	8.75	648	642	6	0.93	0.11	
BJ66-10-G1	500	0	17	17	592	590	2	0.34	0.02	600
(A.F. Data)	510	17	23	6	590	592	-2	-0.34	0.06	
	520	23	31	8	588	588	0	0.00	0	
	530	31	36	5	586	584	2	0.34	0.07	
	540	36	42	6	577	576	1	0.20	0.03	
	550	42	47	5	570	570	0	0.00	0	
	560	47	53	6	560	560	0	0.00	0	
	570	53	59	6	558	558	0	0.00	0	
	580	59	65	6	550	550	0	0.00	0	
	590	65	71	6	534	534	0	0.00	0	
	600	71	77	6	528	530	-2	0.38	-0.06	
	610	77	83	6	524	458	66	12.60	2.10	
BJ66-10-G2	450	0	5	5	587	587	0	0	0	470
(A.F. Data)	460	5	11	6	580	580	0	0	0	
	470	11	25	14	564	564	0	0	0	
	480	30	35	5	560	547	13	2.32	0.46	
	490	35	40	5	560	480	80	14.29	2.86	
BJ66-10-K7	325	0	11.50	11.50	528	534	-6	-1.14	-0.10	>400
(G.E. Data)	350	11.50	22.00	10.50	544	532	12	2.21	0.21	
	400	22.00	33.75	11.75	540	536	4	0.74	0.06	
BJ66-10-K8	325	0	14.25	14.50	608	615	-7	-1.15	-0.08	>400
(G.E. Data)	350	14.25	27.50	13.25	604	590	14	2.32	0.18	
	400	27.50	44.25	16.75	588	592	-4	-0.68	-0.04	

TABLE 20 (Continued)

BJ-Number	Fuel Out Temp., °F	Total Time, Hours			"h_f", BTU/(hr)(ft^2)(°F)				% Loss "h_f"	Interpolated Fuel Temp. for Initial
		Start	End	Δ	Start	End	Δ	%Δ	Per Hour	Loss in "h_f", °F
BJ66-10-K9	325	0	8	8	556	556	0	0	0	350
(G.E. Data)	325	8	19.25	11.25	528	528	0	0	0	
	350	19.25	32.50	13.25	532	532	0	0	0	
	400	32.50	48.50	16.00	520	476	44	8.46	0.53	
(No BJ-Number)										
RAF-177Y-63	400	0	11	11	762	762	0	0	0	460
(A.F. Data)	430	11	18	7	780	780	0	0	0	
	460	18	23	5	780	780	0	0	0	
	480	23	43	20	857	810	47	5.48	0.27	
	490	43	62	19	790	750	40	5.06	0.27	
	510	62	84	22	747	705	42	5.62	0.26	
	525	84	93	9	722	710	12	1.66	0.18	
	530	93	98	5	728	693	35	4.81	0.96	
	550	98	104	6	685	675	10	1.46	0.24	
	580	104	115	11	675	666	9	1.33	0.12	
	600	115	133	18	668	660	8	1.20	0.07	
	620	133	146	13	657	635	22	3.35	0.26	

PHILLIPS 5-ML BOMB THERMAL STABILITY DATA FOR CORRELATION WITH MINEX AND

COKER DATA

TABLE 21

BJ-Number	Log No.	Run Date	Temp. °F,(Y)	Light Transmittance At 350 Millimicrons Before	After	Loss (X)	Regression Data	
BJ62-10-K30	2	7-23-62	322	42	35	7	$\hat{Y} = 4.069X + 284.6$	(a)
			342		27	15	S.E.E. = 12.3	(b)
			365		17	25	TFT_2 = 32.5°F	(c)
			390		14	28		
			404		10	32		
			361		22	20		
	6	7-31-62	345	41	26	15		
			356		23	18		
			382		20	21		
			399		12	29		
			440		10	31		
		8-1-62	367		21	20		
			409		12	29		
			318		32	9		
BJ62-10-K31	3	7-23-62	314	74	62	12	$\hat{Y} = 2.701X + 286.6$	(a)
			348		50	24	S.E.E. = 8.5	(b)
			375		37	37	TFT_2 = 337°F	(c)
			382		34	40		
			400		35	39		
			386		34	40		
			327		58	16		
	6	8-1-62	307		69	5		
			330		59	15		
			370		43	31		
			390		37	37		
			399		34	40		
			358		48	26		
			420		31	43		
BJ63-10-G74	130	3-19-64	387	100.0	83.0	17.0	$\hat{Y}$ = 1.1[illegible]X + 365.5	(a)
			368		94.7	5.3	S.E.E. = 2.5	(b)
			396		75.0	25.0	TFT_2 = 395°F	(c)
			402		68.7	31.3		
			373		95.0	5.0		
			380		87.7	12.3		
			399		73.0	27.0		
			375		92.0	8.0		
			396		70.0	30.0		
BJ63-10-G74	132	3-31-64	392	100.0	69.0	31.0	$\hat{Y} = 1.129X + 359.4$	(a)
			382		81.0	19.0	S.E.E. = 3.8	(b)
			373		92.0	8.0	TFT_2 = 388°F	(c)
			357		97.0	3.0		
			387		79.0	21.0		
			360		97.0	3.0		
			388		76.0	24.0		
			369		94.0	6.0		
			394		67.0	33.0		

(See explanation of footnotes at end of table.)

TABLE 21 (Continued)

BJ-No.	Log No.	Run Date	Temp. °F.(Y)	Light Transmittance At 350 Millimicrons Before	After	Loss(X)	Regression Data	
BJ63-10-G74	136	4-10-64	380	100.0	90.7	9.3	$\hat{Y}$ = 1.454X + 365.4	(a)
			407		70.0	30.0	S.E.E. = 3.7	(b)
			374		93.7	6.3	TFT_2 = 402°F	(c)
			394		80.0	20.0		
			400		82.0	18.0		
			405		72.0	28.0		
			374		94.0	6.0		
			408		70.0	30.0		
			370		94.0	6.0		
BJ64-10-G107	129	3-12-64	386	100.0	92.7	7.3	$\hat{Y}$ = 10.433X + 300.6	(a)
			421		86.7	13.3	S.E.E. = 12.2	(b)
			470		83.3	16.7	TFT_2 = 562°F	(c)
			540		78.7	21.3		
			590		72.0	28.0		
			354		95.0	5.0		
			591		71.0	29.0		
			348		95.3	4.7		
			594		73.0	27.0		
BJ64-10-G107	133	4-2-64	370	97.0	90.7	6.3	$\hat{Y}$ = 10.237X + 312.7	(a)
			464		80.0	17.0	S.E.E. = 12.7	(b)
			570		71.0	26.0	TFT_2 = 561°F	(c)
			356		93.0	4.0		
			587		72.0	25.0		
			395		90.0	7.0		
			602		69.0	28.0		
			357		93.0	4.0		
			600		69.0	28.0		
BJ64-10-G107	178	10-29-64	509	99.0	69.7	29.3	$\hat{Y}$ = 2.800X + 446.2	(a)
			470		84.0	15.0	S.E.E. = 21.3	(b)
			500		82.7	16.3	TFT_2 = 516°F	(c)
			484		81.7	17.3		
			490		79.7	19.3		
			544		79.7	19.3		
			552		62.5	36.5		
			550		67.0	32.0		
			530		66.2	32.8		
BJ64-10-G107	169	10-6-64	420	95.0	73.0	22.0	$\hat{Y}$ = 2.993X + 392.3	(a)
			415		79.0	16.0	S.E.E. = 25.8	(b)
			425		79.6	15.4	TFT_2 = 463°F	(c)
			435		79.3	15.7		
			470		68.8	26.2		
			450		78.0	17.0		
			460		73.8	21.2		
			480		70.5	24.5		
			495		77.5	17.5		
			480		67.6	27.4		

(See explanation of footnotes at end of table.)

TABLE 21 (Continued)

BJ-No.	Log No.	Run Date	Temp. °F.(Y)	Light Transmittance At 350 Millimicrons Before	After	Loss(X)	Regression Data	
BJ64-10-G107	133	4-1-64	376	62.0	36.0	26.0	$\hat{Y} = 2.408X + 313.0$	(a)
			388		31.7	30.3	S.E.E. = 5.8	(b)
			355		49.0	13.0	TFT_2 = 350°F	(c)
			331		57.0	5.0		
			320		58.0	4.0		
			382		32.0	30.0		
			316		58.0	4.0		
			382		32.0	30.0		
			319		58.0	4.0		
BJ64-10-G144	130	3-20-64	413	62.0	34.5	27.5	$\hat{Y} = 2.947X + 320.9$	(a)
			376		40.0	22.0	S.E.E. = 5.9	(b)
			331		58.3	3.7	TFT_2 = 365°F	(c)
			345		53.7	8.3		
			361		49.5	12.5		
			409		30.8	31.2		
			333		58.3	3.7		
			409		32.0	30.0		
			330		58.7	3.3		
BJ64-10-G162	147	5-20-64	408	102.0	67.0	35.0	$\hat{Y} = 1.392X + 360.0$	(a)
			376		92.0	10.0	S.E.E. = 4.6	(b)
			362		96.0	6.0	TFT_2 = 395°F	(c)
			385		90.7	11.3		
			389		83.0	19.0		
			393		78.0	24.0		
			403		69.7	32.3		
			364		97.0	5.0		
			397		76.0	26.0		
BJ64-10-G162	139	4-22-64	357	103.0	87.7	15.3	$\hat{Y} = 1.963X + 332.3$	(a)
			367		77.7	25.3	S.E.E. = 6.7	(b)
			330		97.0	6.0	TFT_2 = 373°F	(c)
			368		84.0	19.0		
			350		89.0	14.0		
			382		69.3	33.7		
			325		98.0	5.0		
			367		85.0	18.0		
			332		98.0	5.0		
BJ64-10-G163	144	5-11-64	459	81.0	65.7	15.3	$\hat{Y} = 7.994X + 357.2$	(a)
			528		58.3	22.7	S.E.E. = 13.2	(b)
			584		53.0	28.0	TFT_2 = 519°F	(c)
			416		74.0	7.0		
			420		72.0	9.0		
			578		55.0	26.0		
			392		79.0	2.0		
			588		53.0	28.0		
			417		73.0	8.0		

(See explanation of footnotes at end of table.)

TABLE 21 (Continued)

BJ-No.	Log No.	Run Date	Temp. °F.(Y)	Light Transmittance At 350 Millimicrons Before	After	Loss(X)	Regression Data	
BJ64-10-G163	146	5-18-64	435	83.0	68.0	15.0	$\hat{Y} = 4.390X + 372.2$	(a)
			391		77.3	5.7	S.E.E. = 11.3	(b)
			503		53.0	30.0	$TFT_2 = 463°F$	(c)
			482		56.0	27.0		
			402		58.7	24.3		
			392		80.0	3.0		
			508		54.0	29.0		
			400		77.0	6.0		
			501		58.0	25.0		
BJ64-10-G166	148	5-25-65	459	105.1	83.7	21.4	$\hat{Y} = 6.170X + 317.8$	(a)
			511		76.7	28.4	S.E.E. = 11.6	(b)
			372		97.0	8.1	$TFT_2 = 480°F$	(c)
			349		101.0	4.1		
			407		88.0	17.1		
			500		74.0	31.1		
			358		99.0	6.1		
			506		74.0	31.1		
			358		97.0	8.1		
BJ64-10-G166	149	5-27-64	358	103.0	95.7	7.3	$\hat{Y} = 5.592X + 318.6$	(a)
			458		78.3	24.7	S.E.E. = 7.5	(b)
			503		72.3	30.7	$TFT_2 = 463°F$	(c)
			485		74.3	28.7		
			425		84.3	18.7		
			358		95.3	7.7		
			502		68.0	35.0		
			358		96.0	7.0		
			498		70.0	33.0		
BJ64-10-G234	207	1-29-65	367	94.3	84.2	10.1	$\hat{Y} = 1.071X + 358.3$	(a)
			380		72.0	22.3	S.E.E. = 2.0	(b)
			375		78.5	15.8	$TFT_2 = 384°F$	(c)
			377		80.5	13.8		
			385		69.2	25.1		
			386		68.7	25.6		
			381		73.5	20.8		
			395		60.5	33.8		
BJ64-10-G234	219	2-19-65	350	95.0	91.3	3.7	$\hat{Y} = 1.205X + 354.0$	(a)
			360		89.3	5.7	S.E.E. = 6.6	(b)
			375		84.0	11.0	$TFT_2 = 383°F$	(c)
			390		66.3	28.7		
			385		73.0	22.0		
			400		53.0	42.0		

(See explanation of footnotes at end of table.)

TABLE 21 (Continued)

BJ-No.	Log No.	Run Date	Temp. °F.(Y)	Light Transmittance At 350 Millimicrons Before	After	Loss(X)	Regression Data
BJ64-10-K26	205	1-26-65	405	26.0	10.0	16.0	$\hat{Y} = 5.875X + 316.3$ (a)
			415		9.1	16.9	S.E.E. = 3.3 (b)
			420		8.8	17.2	TFT_2 = 354°F (c)
			375		16.8	9.2	
			350		20.7	5.3	
			330		23.3	2.7	
			340		21.5	4.5	
			360		19.0	7.0	
			345		20.7	5.3	
			355		19.5	6.5	
B64-10-K26	217	2-17-65	350	29.0	21.6	7.4	$\hat{Y} = 7.426X + 287.7$ (a)
			330		24.0	5.0	S.E.E. = 5.7 (b)
			300		27.0	2.0	TFT_2 = 342°F (c)
			360		18.0	11.0	
			370		17.6	11.4	
			380		16.3	12.7	
			390		16.0	13.0	
			400		14.0	15.0	
			300		27.0	20.0	
BJ64-10-K148	144	5-12-64	500	90.0	73.0	17.0	$\hat{Y} = 11.894X + 307.0$ (a)
			578		67.7	22.3	S.E.E. = 15.6 (b)
			348		87.0	3.0	TFT_2 = 574°F (c)
			432		77.0	13.0	
			630		62.0	28.0	
			351		87.0	3.0	
			626		65.0	25.0	
			347		87.0	3.0	
			632		63.0	28.0	
BJ64-10-K148	145	5-14-64	364	93.0	85.0	8.0	$\hat{Y} = 10.107X + 295.2$ (a)
			512		73.0	20.0	S.E.E. = 12.6°F (b)
			532		67.0	26.0	TFT_2 = 531°F (c)
			425		80.0	13.0	
			580		64.7	23.3	
			580		65.0	28.0	
			360		86.0	7.0	
			574		66.0	27.0	
			359		87.3	5.7	
BJ64-10-L200	146	5-19-64	490	93.0	71.3	21.7	$\hat{Y} = 7.626X + 330.5$ (a)
			552		64.0	29.0	S.E.E. = 12.4 (b)
			455		74.0	19.0	TFT_2 = 508 (c)
			415		80.7	12.3	
			372		89.0	4.0	
			552		64.3	28.7	
			374		87.0	6.0	
			548		67.0	26.0	
			374		88.0	5.0	

(See explanation of footnotes at end of table.)

TABLE 21 (Continued)

BJ-No	Log No.	Run Date	Temp. °F,(Y)	Light Transmittance At 350 Millimicrons Before	After	Loss(X)	Regression Data
BJ65-10-G46	282	8-2-65	335	90.0	86.0	4.0	Note 1
			350		84.6	5.4	TFT_2 = 385°F (c)
			360		79.6	10.4	
			370		76.6	13.4	
			380		77.0	13.0	
			385		71.0	19.0	
			390		60.6	29.4	
			400		57.0	33.0	
			375		77.3	12.7	
			425		38.6	51.4	
			450		42.6	48.4	
			515		38.6	51.4	
			475		46.0	44.0	
BJ65-10-G46A	304	9-28-65	400	84.0	55.0	29.0	Note 1
			350		81.6	2.4	TFT_2 = 397°F (c)
			375		77.0	7.0	
			385		70.0	14.0	
			395		61.6	22.4	
			390		64.6	19.4	
			365		79.0	5.0	
			408		60.0	24.0	
			425		53.6	30.4	
BJ65-10-K25	206	1-28-65	370	98.7	87.2	11.5	$\hat{Y} = 6.409X + 292.6$ (a)
			377		85.7	13.0	S.E.E. = 13.3 (b)
			382		84.3	14.4	TFT_2 = 451°F (c)
			395		82.5	16.2	
			405		80.2	18.5	
			425		77.7	21.0	
			450		73.3	25.4	
			497		71.0	27.7	
			475		66.5	32.2	
			475		69.7	29.0	
			508		67.2	31.5	
BJ65-10-K25	218	2-19-65	350	101.0	87.3	13.7	$\hat{Y} = 6.142X + 273.8$ (a)
			310		97.7	3.4	S.E.E. = 16.9 (b)
			375		82.7	18.8	TFT_2 = 429°F (c)
			335		90.0	11.0	
			390		79.6	21.4	
			405		80.6	20.4	
			400		76.3	24.7	
			420		74.0	27.0	
			440		78.3	22.7	
			450		73.6	27.4	
			465		73.0	28.0	
			485		68.9	32.4	
			530		59.0	42.0	

(See explanation of footnotes at end of table.)

TABLE 21 (Continued)

BJ-No.	Log No.	Run Date	Temp. °F,(Y)	Light Transmittance At 350 Millimicrons Before	After	Loss(X)	Regression Data
BJ65-10-K27	205	1-27-65	385	99.0	89.3	9.7	$\hat{Y} = 8.683X + 319.3$ (a)
			345		96.8	2.2	S.E.E. = 12.6 (b)
			355		94.5	4.5	$TFT_2 = 535°F$ (c)
			368		93.3	5.7	
			475		79.2	19.8	
			460		83.3	15.7	
			485		82.0	17.0	
			500		79.7	19.3	
			552		72.7	26.3	
			578		68.3	30.7	
BJ65-10-K27	215	2-15-65	540	101.5	82.8	19.7	$\hat{Y} = 8.401X + 313.8$ (a)
			540		79.5	23.0	S.E.E. = 38.2 (b)
			500		77.2	24.3	$TFT_2 = 527°F$ (c)
			526		81.0	20.5	
			535		80.0	21.5	
			550		77.3	24.2	
			565		75.5	26.0	
			580		75.3	26.2	
			600		66.8	34.7	
			488		73.8	27.7	
			480		80.7	20.8	
			465		78.[illegible]	23.2	
			465		79.8	21.7	
			590		67.2	34.3	
			452		83.5	18.0	
			400		90.0	11.5	
			480		75.5	26.0	
			350		93.2	8.3	
BJ65-10-K62	326	11-3-65	400	74.0	64.0	10.0	$\hat{Y} = 8.216X + 352.0$ (a)
			450		65.0	9.0	S.E.E. = 15.9 (b)
			550		51.0	23.0	$TFT_2 = 504°F$ (c)
			600		45.0	29.0	
			650		35.6	38.4	
			575		47.0	27.0	
			500		57.0	17.0	
			475		60.0	14.0	
			525		53.6	20.4	
			400		66.0	8.0	
			350		74.0	0	
			375		71.0	3.0	
			425		66.0	8.0	

(See explanation of footnotes at end of table.)

TABLE 21 (Continued)

BJ-No.	Log No.	Run Date	Temp. °F.(Y)	Light Transmittance At 350 Millimicrons Before	After	Loss(X)	Regression Data	
BJ65-10-K71	331	11-17-65	350	101.0	94.7	6.7	Note 1	
			375		59.6	14.4	TFT_2 = 387°F	(c)
			385		86.6	19.4		
			390		81.6	24.7		
			400		76.3	32.0		
			400		69.0	41.4		
BJ65-10-K71	331	11-18-65	300	101.0	99.3	1.7	Note 1	
			350		98.3	2.7	TFT_2 = 387°F	(c)
			375		89.3	11.7		
			385		84.6	16.4		
			390		82.0	19.0		
			395		68.3	32.7		
			400		66.0	35.0		
			450		51.0	50.0		
BJ65-10-K72	332	11-19-65	400	97.0	75.0	22.0	Note 1	
			350		90.0	7.0	TFT_2 = 407°F	(c)
			375		80.6	16.4		
			360		88.5	8.5		
			380		80.0	17.0		
			390		73.6	23.4		
			395		73.3	23.7		
			425		68.0	29.0		
			450		67.0	30.0		
			475		61.0	36.0		
BJ65-10-K73	338	1-3-66	350	99.0	74.0	25.0	$\hat{Y} = 1.211X + 327.6$	(a)
			320		93.0	6.0	S.E.E. = 11.0	(b)
			330		88.0	11.0	TFT_2 = 358°F	(c)
			340		86.0	13.0		
			375		58.0	41.0		
			360		83.0	16.0		
			370		72.0	27.0		
			350		89.0	10.0		
			360		82.0	17.0		
			370		59.0	40.0		
BJ65-10-K74	357	1-20-66	342	69.0	66.0	3.0	$\hat{Y} = 7.846X + 314.0$	(a)
			444		49.0	20.0	S.E.E. = 16.9	(b)
			370		61.3	7.7	TFT_2 = 450°F	(c)
			400		57.3	11.7		
			420		55.3	13.7		
			432		52.0	17.0		
			460		50.0	19.0		
			480		51.0	18.0		
			385		61.0	8.0		
			510		43.0	26.0		
			530		45.0	24.0		

(See explanation of footnotes at end of table.)

TABLE 21 (Continued)

BJ-No.	Log No.	Run Date	Temp. °F,(Y)	Light Transmittance At 350 Millimicrons Before	After	Loss(X)	Regression Data	
BJ65-10-K75	358	1-21-66	387	90.0	67.0	23.0	$\hat{Y} = 3.071X + 318.6$	(a)
			300		88.0	2.0	S.E.E. = 12.6	(b)
			364		81.3	8.7	TFT_2 = 388°F	(c)
			375		72.0	18.0		
			330		88.3	1.7		
			420		56.6	33.4		
			405		59.3	30.7		
			395		66.6	23.4		
			370		75.0	15.0		
BJ65-10-K76	355	1-19-66	370	92.0	65.0	27.0	$\hat{Y} = 1.648X + 328.3$	(a)
			326		85.3	6.7	S.E.E. = 8.0	(b)
			355		71.3	20.7	TFT_2 = 366°F	(c)
			395		54.0	38.0		
			340		87.0	5.0		
			365		71.0	21.0		
			380		59.0	33.0		
			350		87.3	10.7		
			360		80.3	11.7		
BJ65-10-K77	360	1-24-66	385	86.0	65.0	21.0	$\hat{Y} = 2.476X + 333.7$	(a)
			358		77.0	9.0	S.E.E. = 5.7	(b)
			330		84.0	2.0	TFT_2 = 388°F	(c)
			375		73.0	13.0		
			400		58.0	28.0		
			380		69.0	17.0		
			396		61.0	25.0		
			410		54.0	32.0		
BJ66-10-G1	364	1-26-66	410	33.0	30.6	2.4	$\hat{Y} = 40.274X + 326.9$	(a)
			457		29.3	3.7	S.E.E. = 25.5	(b)
			508		28.3	4.7	TFT_2 = 649°F	(c)
			578		27.0	6.0		
			602		26.6	6.4		
			646		25.0	8.0		
			678		25.0	8.0		
			768		21.0	12.0		
			720		24.0	9.0		
BJ66-10-G2	363	1-25-66	369	98.0	88.0	10.0	$\hat{Y} = 2.167X + 339.3$	(a)
			450		54.6	43.4	S.E.E. = 9.6	(b)
			412		60.6	37.4	TFT_2 = 392 °F	(c)
			380		74.6	23.4		
			340		96.0	2.0		
			360		92.0	6.0		
			376		80.3	17.7		
			407		66.0	32.0		
			397		68.0	30.0		

(See explanation of footnotes at end of table.)

TABLE 21 (Continued)

BJ-No.	Log No.	Run Date	Temp. °F,(Y)	Light Transmittance At 350 Millimicrons Before	After	Loss(X)	Regression Data	
BJ66-10-K7	403	2-25-66	340	60.0	55.6	4.4	$\hat{Y} = 3.554X + 315.8$	(a)
			450		29.0	31.0	S.E.E. = 12.7	(b)
			360		45.6	14.4	TFT_2 = 369°F	(c)
			381		40.6	19.4		
			401		32.0	28.0		
			330		57.0	3.0		
			390		36.0	24.0		
			350		52.0	8.0		
			310		60.0	0		
BJ66-10-K8	403	2-28-66	435	100.0	56.0	44.0	$\hat{Y} = 2.843X + 310.3$	(a)
			310		96.0	4.0	S.E.E. = 7.4	(b)
			396		70.0	30.0	TFT_2 = 381°F	(c)
			325		93.0	7.0		
			340		93.0	7.0		
			361		85.0	15.0		
			376		79.0	21.0		
			385		73.0	27.0		
			405		65.0	35.0		
BJ66-10-K9	405	3-1-66	360	96.0	86.0	10.0	$\hat{Y} = 2.108X + 331.1$	(a)
			314		94.0	2.0	S.E.E. = 10.9	(b)
			375		77.0	19.0	TFT_2 = 382°F	(c)
			370		84.0	12.0		
			390		67.0	29.0		
			380		76.0	20.0		
			399		61.0	35.0		
			385		68.0	28.0		
			340		93.0	3.0		

NOTE 1: Linear regression equation not determined since data points are curvilinear. Threshold failure temperatures obtained graphically.

(Y) The dependent variable (Y-axis) in the regression equation.

(X) The independent variable (X-axis) in the regression equation.

(a) Linear regression equation representing experimental data in terms of units loss.

(b) Standard Estimate of Error (Sy.x) of regression data in terms of the dependent variable (°F).

(c) TFT_2 is the predicted temperature based on 25 per cent loss in initial light transmittance at 350 millimicrons wave length.

TABLE 22

COKER DATA FOR CORRELATION WITH 5-ML BOMB AND MINEX

Notes: All Coker Data at Ambient Reservoir
All Filter Temperatures 100°F Above
Preheater Temperatures

BJ-Number	Other Identification	Coker Data, Source	Coker Config.	Preheater Tem, °F	Unwiped Preheater Code, Max.	Interpolated Threshold Failure Temp., °F
BJ62-10-K30	G.E. Kerosine	e	ASTM	350	2	388
				375	2	
				400	4	
BJ62-10-K31	G.E. JP-6	e	ASTM	375	0	418
				400	2	
				425	4	
BJ63-10-G74	RAF-176-63	a	ASTM	300	0	374
				325	2	
				350	2	
				350	0	
				350	1	
				375	2	
				375	4	
				400	1	
				400	4	
BJ63-10-G74	RAF-176-63	a	ASTM	375	6	36.1
				350	1	
BJ63-10-G74	RAF-176-63	c	ASTM	325	2	338
				350	4	
				375	7	
BJ63-10-G74	RAF-176-63	b	ASTM	325	0	367
				350	1	
				375	4	
BJ63-10-G74	RAF-176-63	b	ASTM	325	0	370
				350	0	
				375	4	
BJ63-10-G74	RAF-176-63	a	RES	350	1	363
				375	5	
				400	7	

(See end of table for explanation of footnotes.)

TABLE 22 (Continued)

BJ-Number	Other Identification	Coker Data, Source	Coker Config.	Preheater Temp., °F	Unwiped Preheater Code, Max.	Interpolated Threshold Failure Temp., °F
BJ63-10-G74	RAF-176-63	d	SSF	375	3	375
				350	3	
				325	1	
				325	1	
				350	1	
				350	1	
BJ64-10-G107	RAF-169YX-61	a	RES	500	1	700
				550	1	
				600	1	
				700	3	
				750	3	
BJ64-10-G107	RAF-169YX-61	a	RES	600	5	<450
				500	3	
				450	3	
BJ64-10-G107	RAF-169YX-61	d	SSF	750	2	692
				800	3	
				850	4	
				825	4	
				775	2	
				800	4	
				775	2	
BJ64-10-G162	RAF-174-63	a	ASTM	325	1	361
				375	6	
				350	1	
BJ64-10-G162	RAF-174-63	c	ASTM	325	1	342
				300	1	
				375	4	
				350	4	
BJ64-10-G162	RAF-174-63	e	ASTM	375	0	388
				400	1	
				425	5	
BJ64-10-G162	RAF-174-63	e	ASTM	325	2	335
				350	5	
				375	6	
BJ64-10-G162	RAF-174-63	e	ASTM	350	0	385
				375	1	
				400	6	
				400	6	

(See end of table for explanation of footnotes.)

TABLE 22 (Continued)

BJ-Number	Other Identification	Coker Date, Source	Coker Config.	Preheater Temp. °F	Unwiped Preheater Code Max.	Interpolated Threshold Failure Temp., °F
BJ64-10-G162	RAF-174-63	e	ASTM	300	1	367
				300	2	
				325	4	
				325	1	
				350	1	
				350	4	
				375	3	
				375	4	
BJ64-10-G162	RAF-174-63	a	RES	400	7	354
				350	3	
				325	1	
				375	7	
				375	1	
				425	6	
				400	7	
BJ64-10-G162	RAF-174-63	e	RES	375	1	390
				400	7	
				425	6	
BJ64-10-G162	RAF-174-63	e	RES	350	1	360
				375	6	
				400	6	
BJ64-10-G162	RAF-174-63	e	RES	325	1	357
				350	2	
				375	6	
				375	6	
BJ64-10-G162	RAF-174-63	e	RES	325	2	335
				325	1	
				350	6	
				350	6	
				375	6	
BJ64-10-G162	RAF-174-63	e	SSF	375	2	387
				400	4	
				425	4	
BJ64-10-G162	RAF-174-63	e	SSF	350	1	387
				375	2	
				375	3	
				375	1	
				375	2	
				400	4	
				400	4	

(See end of table for explanation of footnotes.)

TABLE 22 (Continued)

BJ-Number	Other Identification	Coker Date, Source	Coker Config.	Preheater Temp., °F	Unwiped Preheater Code Max.	Interpolated Threshold Failure Temp., °F
BJ64-10-G107	RAF-174-63	e	SSF	325	1	368
				350	6	
				350	1	
				375	4	
				375	6	
				400	6	
BJ64-10-G163	RAF-175YX-63	e	ASTM	425	2	437
				450	4	
BJ64-10-G163	RAF-175YX-63	a	RES	400	1	435
				500	6	
				450	6	
				425	1	
BJ64-10-G163	RAF-175YX-63	c	RES	450	4	427
				425	5	
				450	6	
				425	1	
				400	1	
				400	2	
BJ64-10-G163	RAF-175YX-63	e	RES	400	2	408
				425	5	
BJ64-10-163	RAF-175YX-63	e	SSF	475	5	450
				450	3	
				425	1	
BJ64-10-G166	Storage Fuel 5	c*	ASTM	450	3	425
				400	1	
				425	3	
				425	2	
				475	3	

*This fuel is designated as RAF-179-64 in report (c) but in reality is a fuel only similar to RAF-179-64 but is identical to Storage Fuel 5 used in Phillips storage program.

BJ-Number	Other Identification	Coker Date, Source	Coker Config.	Preheater Temp., °F	Unwiped Preheater Code Max.	Interpolated Threshold Failure Temp., °F
BJ64-10-G166	Storage Fuel 5	d	SSF	375	2	425
				425	4	
				400	2	
				400	2	
				425	2	
				450	3	
				425	4	
				450	4	
				475	5	

(See end of table for explanation of footnotes.)

TABLE 22 (Continued)

BJ-Number	Other Identification	Coker Date, Source	Coker Config.	Preheater Temp., °F	Unwiped Preheater Code, Max.	Interpolated Threshold Failure Temp., °F
BJ64-10-G234	RAF-176-64	b	ASTM	325	1	363
				350	1	
				375	5	
BJ64-10-G234	RAF-176-64	a	ASTM	325	1	368
				350	1	
				375	5	
				400	6	
BJ64-10-G234	RAF-176-64	a	ASTM	325	0	384
				325	1	
				325	0	
				325	2	
				325	1	
				350	1	
				350	1	
				350	0	
				350	2	
				350	1	
				375	0	
				375	0	
				375	5	
				375	0	
				375	2	
				375	5	
				400	6	
				400	4	
				400	6	
BJ64-10-G234	RAF-176-64	b	ASTM	375	0	394
				400	4	
BJ64-10-G234	RAF-176-64	a	RES	350	2	363
				400	6	
BJ64-10-G234	RAF-176-64	b	RES	350	2	375
				375	3	
				400	6	
BJ65-10-K26	FA-S-1	b	ASTM	325	2	338
				350	4	
				375	4	
BJ65-10-K26	FA-S-1	b	ASTM	300	1	368
				350	2	
				400	5	

(See end of table for explanation of footnotes.)

TABLE 22 (Continued)

BJ-Number	Identification	Coker Data, Source	Coker Config.	Preheater Temp., °F	Unwiped Preheater Code, Max.	Interpolated Threshold Failure Temp., °F
BJ65-10-K26	FA-S-1	b	ASTM	300 325 350	2 3 5	325
BJ65-10-K26	FA-S-1	b	ASTM	300 350 375 400	2 2 4 4	363
BJ65-10-K26	FA-S-1	b	ASTM	325 350 375	2 3 5	350
BJ65-10-K26	FA-S-1	b	ASTM	300 325 350	1 3 6	325
BJ65-10-K26	FA-S-1	b	ASTM	300 325	2 6	313
BJ65-10-K26	FA-S-1	b	RES	275 300 325 350	1 1 2 3	350
BJ64-10-K148	F-63-18(563)	c	RES	525 550 600 500 525	2 2 5 3 4	537
BJ64-10-L200	RAF-159X-60	a	RES	700 650 600 500 750 750	6 3 3 1 3 4	655
BJ65-10-G46	G.E. 465	e	ASTM	375	3	375
BJ65-10-G46A	G.E. 465A	e	ASTM	375	3	375
BJ65-10-K25	FA-S-2A	b	ASTM	400 425 450	1 1 3	450

(see end of table for explanation of footnotes.)

TABLE 22 (Continued)

BJ-Number	Other Identification	Coker Data, Source	Coker Config.	Preheater Temp., °F	Unwiped Preheater Code Max.	Interpolated Threshold Failure Temp., °F
BJ65-10-K25	FA-S-2A	b	ASTM	375	1	450
				425	2	
				450	4	
				450	3	
				475	4	
BJ65-10-K25	FA-S-2A	b	RES	450	2	467
				475	4	
				500	4	
BJ65-10-K27	FA-S-2B	b	ASTM	400	1	450
				425	2	
				450	3	
BJ65-10-K27	FA-S-2B	b	ASTM	375	2	450
				425	2	
				450	2	
				475	3	
BJ65-10-K62	G.E. 965-1	e	ASTM	350	1	378
				375	2	
				400	6	
BJ65-10-K71	RAF-176A-63	a	ASTM	325	2	336
				350	4	
				375	7	
BJ65-10-K72	G.E. 965-2	e	ASTM	350	2	375
				375	3	
				400	6	
BJ65-10-K72	G.E. 965-2	e	ASTM	325	2	350
				350	3	
				375	6	
BJ65-10-K73	G.E. 965-3	e	ASTM	350	1	388
				375	2	
				400	4	
BJ65-10-K76	G.E. 1265-2	e	ASTM	300	1	392
				325	1	
				350	1	
				375	1	
				400	4	

(See end of table for explanation of footnotes.)

TABLE 22 (Continued)

BJ-Number	Other Identification	Coker Data, Source	Coker Config.	Preheater Temp., °F	Unwiped Preheater Code, Max.	Interpolated Threshold Failure Temp., °F
BJ65-10-K77	G.E. 1265-2A	e	ASTM	425	2	440
				450	4	
BJ66-10-G1	RAF-167YX-60	a	RES	500	7	<450
				500	6	
				450	7	
- - - - -	RAF-177Y-63	c	RES	450	1	475
				550	6	
				500	7	
				475	3	

a CRC Report No. LD-148

b North American Aviation Report NA-65-753

c Air Force Report AFAPL TR 64-154

d Air Force Report APL TDR 64-89 Part II

e Unpublished Industry Data

TABLE 23

PHYSICAL AND CHEMICAL PROPERTIES--TEST METHODS

Tests	Test Methods
Distillation, °F	ASTM D-86
Smoke point, Mm	ASTM D1322-59T
API Gravity @ 60°F	ASTM 287-55
Existent gum, Mg/100 ml	ASTM D381-58T
Total potential gum, Mg/100 ml	ASTM D873-57T
Insoluble potential gum, Mg/100 ml	ASTM D873-57T
Lamp sulfur (Wichbold), ppm	ASTM D1266
Mercaptan sulfur, ppm	$Hg(ClO_4)_2$ Titration
Freezing point, °F	ASTM D1477-57T
Net heating value, Btu/lb	Fed. Std. No. 791-2502
Kinematic viscosity, cs @ -40°F	ASTM D445-53T
Aromatics, Vol % (FIA)	ASTM D1319-58T
Olefins, bromine no., Vol %	Colorimetric Method
Corrosion, copper strip	ASTM D130-56
Water reaction	ASTM D1094-57
Aniline point, °F	ASTM D611-55T
Neutralization No., Mg KOH/gram	ASTM D664-58
Flash point, °F	ASTM D93-58T
Total naphthalenes, Wt %	Ultraviolet spectrophotometry
Indenes, ppm	Anal. Chem. 21, 1528 (1949)
Pyrrole nitrogen, ppm	Anal. Chem. 30, 1528 (1958)
Basic nitrogen, ppm	Phillips Method 142-57R
Total nitrogen, ppm	Anal. Chem. 30, 1528 (1958)
Trace copper, ppb	Phillips Method MR-60R
Soluble iron, ppm	Phillips Method OG-61R
Soluble lead, ppb	Phillips Method 100-58R
Water Content, ppm	Karl Fisher
Phenols, ppm	Ind. Engr. Chem. Anal. Ed. 18,103 (1946)
Peroxides, ppm	Phillips Method 133-57R
Dissolved oxygen, ppm	Phillips Chromatographic Method RK-63R
Total oxygen, Wt %	Direct Combustion and Adsorption
Hydrogen content, Wt %	Direct Combustion and Adsorption
Saybolt color	ASTM D156-53T
% Light transmittance @ 350 mμ (iso C_8 = 100%)	Bausch & Lomb Spectronic 20 spectrophotometer
Threshold failure temperature, °F	Phillips Modified 5-ml Bomb and SSF Coker

TABLE 24

PHYSICAL AND CHEMICAL PROPERTIES OF JET FUELS FOR STORAGE PROGRAM

Storage Fuel No.	1	2	3	4	5
Distillation, °F					
IBP	362	332	361	381	356
10%	372	361	382	400	386
50%	394	402	420	418	422
90%	480	464	463	456	474
EP	552	508	512	502	511
Residue, Vol. %	2.0	1.0	0.5	1.0	1.0
Dist. Loss, Vol. %	0.0	0.0	0.0	0.0	0.0
Smoke point, mm	41.0	22.8	21.8	36.4	28.6
API Gravity @ 60°D	52.5	43.9	36.7	46.7	44.0
Existent gum, mg/100 ml	1.1	0.0	0.0	0.0	0.2
Total potential gum, mg/100 ml	6.6	0.2	7.0	0.7	3.8
Insoluble potential gum, gm/100 ml	1.1	0.2	0.3	0.5	0.0
Lamp sulfur, ppm	3	820	47	28	10
Mercaptan sulfur, ppm	< 2	4	< 2	< 2	< 2
Freezing point, °F	-78	-58	-100	-72	-46
Net heating value, Btu/lb	18,950	18,550	17,500	18,700	18,550
Kinematic viscosity, cs @ -40°F	21.34	10.14	21.33	14.28	13.21
Aromatics, Vol % (FIA)	3.4	15.5	2.3	1.8	14.5
Olefins, Vol %	1.79	< 0.10	0.41	0.12	0.21
Corrosion, copper strip	1A	1A	1A	1A	1A
Water reaction	1	1	0	0	1
Neutralization No., mg KOH/gram	0.05	0.07	< 0.05	0.05	< 0.05
Aniline point, °F	189.2	143.3	143.2	165.5	148.3
Flash Point, °F	144	130	146	160	146

(Continued)

TABLE 24 (Continued)

Storage Fuel No.	1	2	3	4	5
Total Naphthalenes, Wt %	<1	2.0	<1	<1	2.0
Indenes, ppm	<5	<5	<5	<5	<5
Pyrrole nitrogen, ppm	0.10	0.30	0.01	0.02	0.15
Basic nitrogen, ppm	<1.0	2.3	1.1	<1.0	2.0
Total nitrogen, ppm	<1	2	5	4	<1
Trace copper, ppb	<10	21	<10	18	<10
Soluble iron, ppm	<1	<1	<1	<1	<1
Soluble lead, ppb	7	10	16	19	13
Water content, ppm	20	23	17	10	40
Phenols, ppm	<2	18	<2	<2	<2
Peroxides, ppm	<2	<2	<2	2	<2
Dissolved oxygen, ppm	74	59	53	64	62
Total oxygen, Wt %	0.079	0.098	0.120	0.210	0.400
Hydrogen content, Wt %	15.1	14.0	13.8	14.2	13.9
Saybolt color	+27	+18	+28	+29	+30
% Light transmittance @ 350 Mμ (iso C_8 = 100%)	63.4	98.0	93.6	97.3	98.9
Threshold failure temperature, °F (Phillips Modified 5-ml Bomb - 25% Loss Rating Criterion)	503	395	517	526	471
Threshold failure temperature, °F (SS Fuel Coker)	625	332	712	692	425